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# ARCHIVES OF SURGERY

VOL. 3

JULY, 1921

No. 1

## THE ANATOMY AND SURGERY OF THE TRIGON \*

HUGH H. YOUNG, M.D. AND MILEY B. WESSON, M.D.  
BALTIMORE

The trigonal muscle is of particular interest in a study of the mechanism of micturition, because of its peculiar anatomy and close relationship with the so-called vesical sphincters. The opening of the internal "sphincter" during micturition was formerly considered as an inhibitory action. We now believe that the contraction of the powerful trigonal muscle passing in the form of a bow through the weaker arcuate muscles at the vesical orifice helps mechanically to pull open the "sphincter." This view is confirmed by endoscopic and cystoscopic studies, as the trigonal muscle is seen to contract and pull open the vesical orifice.

Obstruction to urination is generally followed by a partial or complete compensatory hypertrophy of the trigon. Upon removal of the obstruction, there is a corresponding compensatory trigonal atrophy. Occasionally following marked obstruction there is an undermining of the trigon, the hypertrophied muscle being dissected away from the bladder wall. Upon contraction it stands up as a ledge dividing the bladder into two parts, mechanically preventing the complete emptying of the bladder. Furthermore, the contractile force of such a trigon is not properly applied to expedite the opening of the vesical orifice. With the removal of the obstruction by splitting the damlike ledge, the trigon is able to resume its normal functions. However, if there has been a complete removal of the trigon, micturition is not normal in that the bladder is not completely emptied.

### MORPHOLOGY

The trigon (tr. Lieutaudii) is a smooth triangular area lying in the base of the bladder, having the two ureters and the vesical orifice at its angles. It is better to conceive of the trigon as a region rather than to assign this name to any structure or structures. In the trigonal region are the two muscle layers of the bladder wall, the external longitudinal and the internal circular, and superimposed upon these is the sub-

\* From the James Buchanan Brady Urological Institute, Johns Hopkins Hospital.

mucous or trigonal muscle, which is an extension of the longitudinal muscle layer of the ureters and their sheaths.<sup>1</sup> It consists of fibers extending fanwise from the ureteral orifices, some fibers passing medially, going to make up Mercier's bar, others interlacing with corresponding fibers from the opposite side in the middle of the trigon, and still others passing down to the urethra and making up Bell's <sup>2</sup> muscles. The Bell's muscles of the two sides converge at the vesical orifice, causing the trigonal muscle at this point to be denser and thicker.<sup>3</sup> Where the thickened layer passes over the edge of the vesical orifice, it makes up the principal portion of the uvula of Lieutaud.

The mucous membrane of the trigon differs from that of the remainder of the bladder in that it is so firmly adherent to the subjacent tissue as to present rarely any rugae even when the bladder is empty, thus preventing any prolapse of the mucous membrane into the vesical orifice during micturition.<sup>4</sup> Subtrigonal glands occur commonly in the anterior half of the trigon, lying between the vesical orifice and the middle of the trigon.<sup>5</sup> They are generally simple tubules lying in the mucosa though they may have one or two small branches, and extend superficially into the muscle layer. They do not have definite connective tissue or other differentiated envelopes surrounding them. In our series we saw three hypertrophies of this group, the tumor masses appearing to be about 1 cm. in diameter and 0.5 cm. in height. They are of little clinical importance (Fig. 1).

The observation made of the gross specimens studied show that no rules can be deduced as to shape <sup>6</sup> and size <sup>7</sup> of the trigon, as it displays

---

1. Satani, Y.: Histologic Study of the Ureter, *J. Urol.* **4**:247, 1919.  
Waldeyer, W.: *Das Trigonum vesicae*, *Sitzungsb. d. k. Akad. d. Wissensch. Math.-naturw. Cl.*, 1897, p. 732.

2. Bell, C.: Account of the Muscles of the Ureters and Their Effects on the Irritable State of the Bladder, *Med.-Chir. Tr.* **3**:171-190, 1812.

3. Ellis, G. V.: An Account of the Arrangement of the Muscular Substance in the Urinary and Certain of the Generative Organs of the Human Body, *Med.-Chir. Tr.* **39**:327-338, 1856.

4. Treves, F.: *Surgical Applied Anatomy*, Ed. 7, London, Cassell & Co., 1918, p. 475.

5. Lowsley, O. S.: The Gross Anatomy of the Human Prostate Gland and Contiguous Structures, *Surg., Gynec. & Obst.* **20**:183-192, 1915; The Development of the Human Prostate Gland with Reference to the Development of Other Structures at the Neck of the Urinary Bladder, *Am. J. Anat.* **13**:299-346, 1912.

6. Disse, J.: Die Harnblase, in *Handb. d. Anat. d. Mensch.* Jena, Bardeleben **7**: Pt. 1, 113-169, 1902. Testut, L.: Vessie, in *Traité d'anatomie humaine*, Paris **3**:869-895, 1894.

7. Schewkunenko, W. N.: Portion intraparietale de l'uretere et trigone vesical, leurs differentes formes, *J. d'urolog. méd. et chir.* **1**:131, 1912.

great individual variations, independent of age, sex or size of the bladder.<sup>8</sup> The size of the ureteral orifices and the topography in relation to the interureteral ridge vary greatly; but both ureteral openings are never on the same side of the median line.<sup>9</sup> When there are supernumerary ureters opening into the bladder, the meatus of each as a rule lies in the trigon.<sup>10</sup> Delbet<sup>11</sup> states that in congenital absence of the ureter the corresponding side of the trigon is lacking.

#### MUSCULATURE OF THE VESICAL NECK

The development of the trigon was studied by one of us,<sup>12</sup> using a series of thirty human embryos from the Carnegie Institute of Embryology. This work was supplemented by a study of serial sections

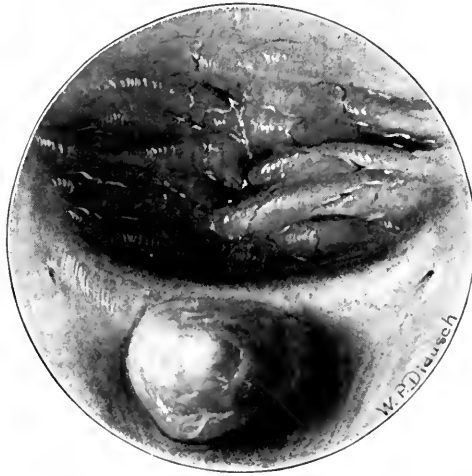


Fig. 1.—Hypertrophy of subtrigonal gland (B. U. I., No. 2,129).

of trigons from adults. Glass models were made of the neck of the bladder of a 7½ months' fetus, cut sagittally, and of a term fetus, cut transversely. Preparations of the gross trigon were made by floating

8. Krasa, F. C., and Paschkis, R.: *Das Trigonum vesical der Säugetiere*, Ztschr. f. urol. Chir. **6**:1-52, 1921. Whiteside, G. S.: *The Measurements of the Trigon*, Med. Sentinel **12**:553-560, 1904.

9. Uteau, R.: *Anatomie du trigone vesical*, Ann. d. mal. d. org. génito-urin. **23**:241-290, 1905.

10. Mertz, H. O.: *A Review of the Subject of Multiple Ureters with a Study of Sixteen Unpublished Cases*, Urol. & Cutan. Rev. **22**:553-565, 1918.

11. Delbet, P.: *Vessie*, in *Traité d'anatomie humaine*, Paris, Poirier and Charpy **5**:74-126, 1901.

12. Wesson, M. B.: *Anatomical, Embryological and Physiological Studies of the Trigon and Neck of the Bladder*, J. Urol. **4**:279-315 (June) 1920.

the trigonal muscle off the bladder wall by Mall's<sup>13</sup> acetic acid method (Fig. 2). The arrangement of the muscles of the so-called internal sphincter was verified by a study of specimens macerated in hydrochloric acid and teased out with needles.

The bladder has an internal circular and an external longitudinal layer of smooth muscle, which are not perfectly defined. Confusion is increased by the fact, to which Howell<sup>14</sup> calls attention, that the direction of these fibers and the number of layers into which they can be separated depend to a large extent on the state of distention of the bladder, as the muscle fibers rearrange themselves during changes in the size of the bladder. In the trigonal region, there is in addition the trigonal muscle which embryologically is of mesodermal origin, while the external longitudinal and internal circular layers arise from tissues of entodermal origin.<sup>15</sup>

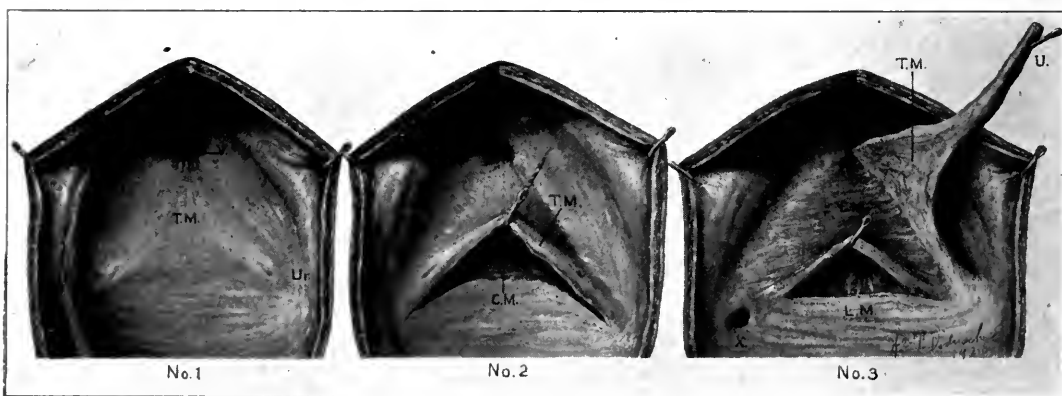


Fig. 2.—1, normal trigon; 2, trigonal muscle raised exposing the circular muscle layer; 3, left ureter dissected free from the bladder wall and trigonal muscle pulled up as a sheet. The line of cleavage is marked by a layer of blood vessels. The external longitudinal layer of muscle is exposed by lifting the circular layer: *V*, vesical orifice; *U*, ureter; *Ur*, ureteral orifice; *TM*, trigonal muscle; *CM*, circular muscle; *LM*, longitudinal muscle; *X*, opening from which ureter was removed.

In considering the muscular mechanism, making up what has been called the internal sphincter of the bladder, the reader is referred to Figure 3 and the accompanying diagram (Fig. 4) made from the glass models.

13. Mall, F. P.: Reticulated Tissue and Its Relation to the Connective Tissue Fibrils, Johns Hopkins Hosp. Rep. **1**:171-208, 1896.

14. Howell, W. H.: A Text-Book of Physiology, Ed. 7, Philadelphia, 1918, W. B. Saunders Company, p. 863.

15. Felix, W.: The Development of the Urogenital Organs, in Manual of Human Embryology, Philadelphia, Keibel and Mall **2**:752-979, 1912.



The fibers of the external longitudinal layer sweep down along the posterior surface of the bladder until they reach the region of the vesical orifice where many of them end. The elastic fibers continue and form a sort of tendinous arrangement connecting with the denser layers about the vesical orifice. A portion, however, of those fibers which sweep along the back of the bladder diverge slightly to form muscular bands which pass forward and downward on either side of the vesical orifice (Fig. 5). At the upper level of the urethra these two bands swing

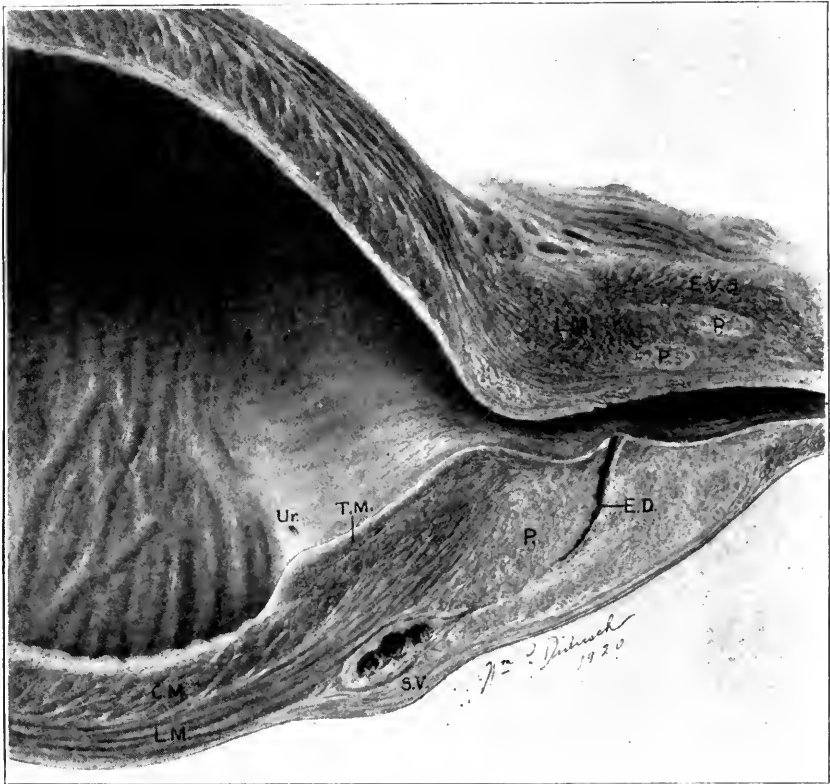


Fig. 3.—Sagittal section through urethra of adult.

medially and unite to form a loop or arch about the urethra. The fibers pass freely through this loop, and there is no raphé formation. A cross-section of this loop, where it passes in front of the urethra, is shown in the diagram (Fig. 4). The longitudinal fibers sweeping down the anterior surface of the bladder end for the most part at the vesical orifice; but a few pass along the anterior aspect of the prostatic urethra just beneath the mucosa, forming an internal longitudinal layer of the urethra, corresponding to the trigonal fibers on the posterior aspect.

The circular fibers pass around the bladder until a point is reached just opposite the vesical neck. Here some of the fibers from the region posterior to the vesical orifice swing downward and forward in an oblique direction, passing as thin bands inside the loop of the external longitudinal muscle described above and swinging around the urethra in the region generally opposite the verumontanum where they also form a loop or arch in front of the urethra. This arrangement leaves

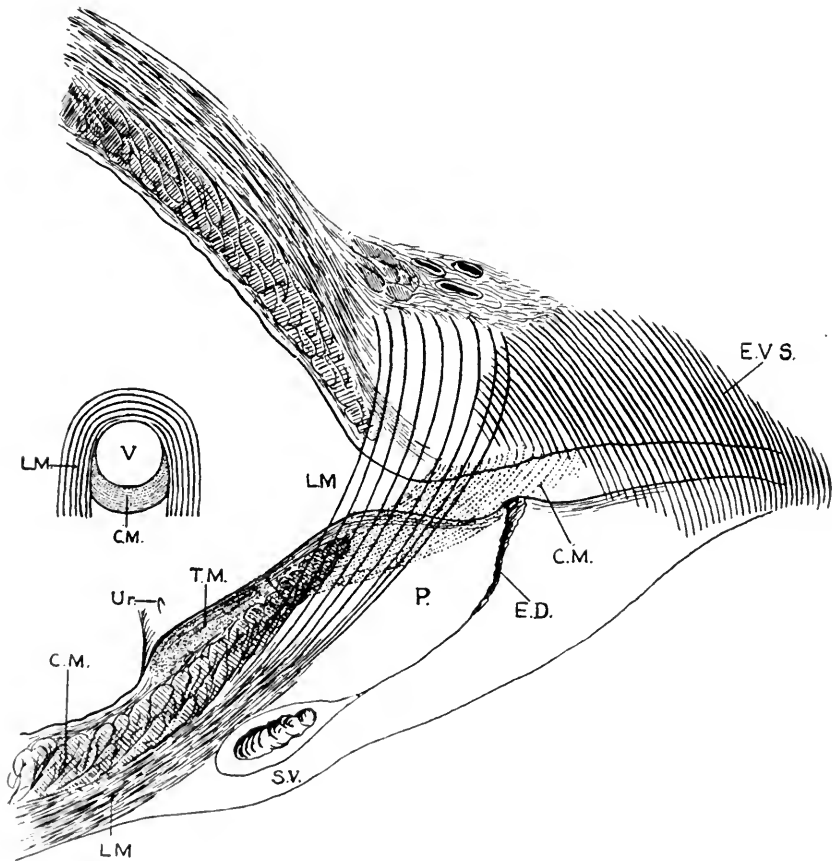


Fig. 4.—Sagittal section of bladder (diagram of Figure 3). The external longitudinal layer of the base sweeps up over the vesical orifice making a loop. Within this loop the circular layer forms a wedge below the orifice and flows down the urethra in an oblique direction surrounding the canal as a thin layer. The result is a double loop and not a sphincter. The small inset is a cross-section of the vesical orifice, showing the upward pull of the loop from the circular muscle and the opposing action of the longitudinal muscle loop. *V*, vesical orifice; *LM*, longitudinal muscle; *CM*, circular muscle; *TM*, trigonal muscle; *EVS*, external vesical sphincter (striated muscle); *Ur*, ureteral orifice; *SV*, seminal vesicle; *ED*, ejaculatory duct; *P*, prostate.

a short length of the urethra extending anteriorly from the vesical orifice about half way down to the verumontanum, without any investment of fibers arising from the internal circular layer (Fig. 6). Other fibers, branching off from this band as it passes downward and forward in its oblique course, extend into the prostate gland. Their course cannot be followed among the prostatic tubules. It seems probable, however, that the prostate represents the posterior portion of this collection of circular fibers extending down around the urethra, which has been invaded and distorted by prostatic tubules.

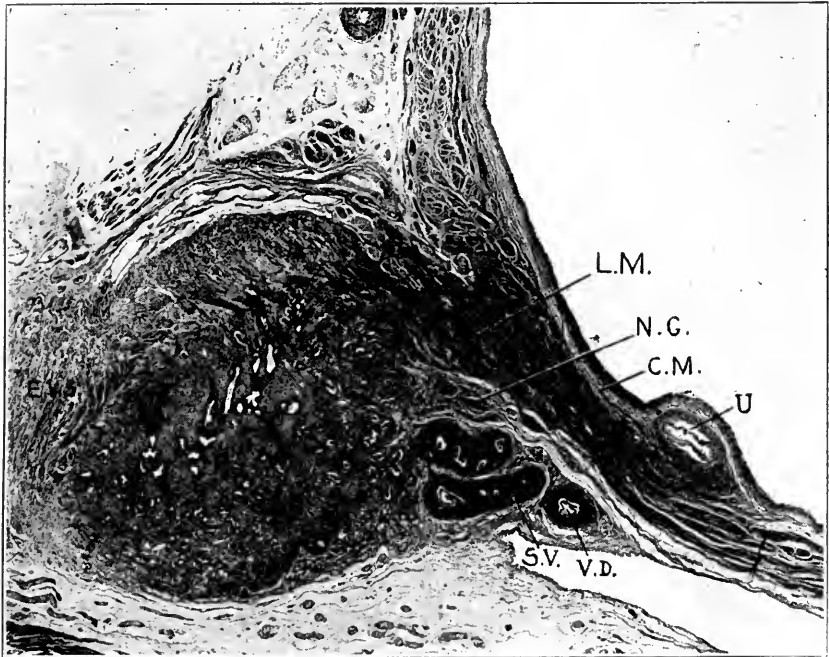


Fig. 5.—A sagittal section through lateral lobe of prostate of 240 mm. human embryo. The longitudinal layer of the base is sweeping out over the urethra making a crus over the orifice: *U*, ureter; *SV*, seminal vesicle; *VD*, vas deferens; *P*, prostate; *EVS*, external vesical sphincter; *LM*, longitudinal muscle; *CM*, circular muscle; *NG*, nerve ganglia (Embryo, Carnegie Institute 2671b, slide 46, row 2, sec. 1);  $\times 9$ .

The trigonal muscle, as has been described above, passes down over the posterior border of the vesical orifice and spreads out as an internal longitudinal layer over the posterior aspect of the urethra. The fibers pass between the openings of the prostatic ducts, ejaculatory ducts and prostatic utricle, and continue on down for some distance past the verumontanum. Some fibers may be traced as far as the beginning of the membranous urethra.

At a point opposite the mediolateral aspect of the vesical orifice, there may be found lying in close relationship to the fibers of the loop of the external longitudinal muscle, a few striated muscle fibers. These fibers are often quite close to the urethral mucosa and even lie between the prostatic tubules. As they pass downward and forward, they

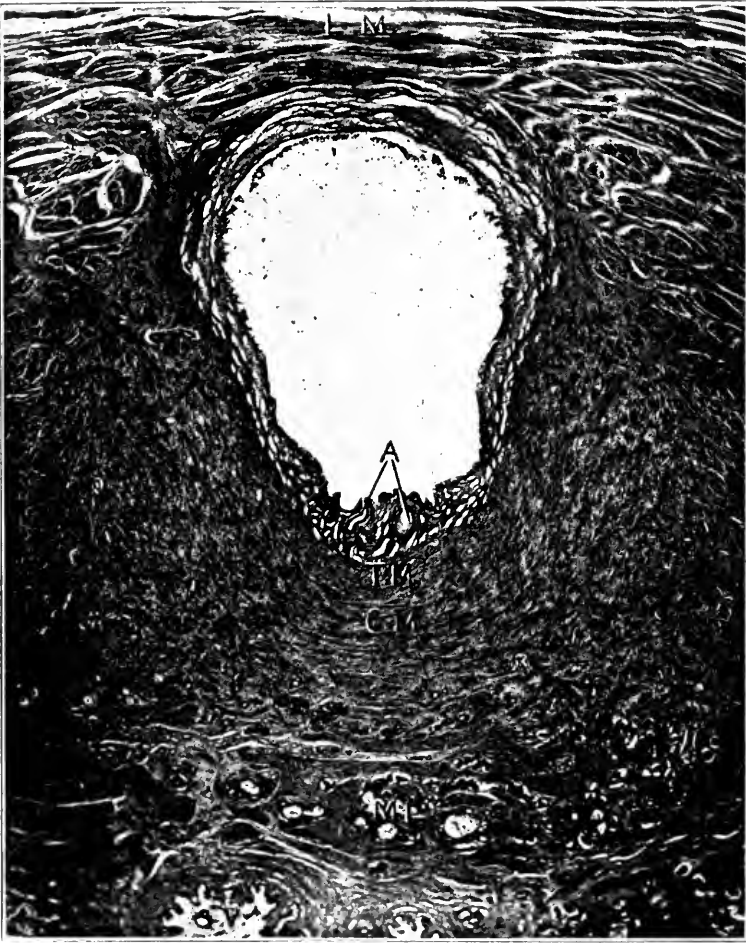


Fig. 6.—Cross-section through distal part of vesical orifice of a term human fetus. The circular layer of muscle (internal arcuate muscle) hugs the urethra but reaches only to the midlateral wall. Tubules of Albarran's glands are seen extending down through the mucosa almost to the submucous trigonal muscle. Above the urethra is the external longitudinal layer (external arcuate muscle): *L.M.*, external arcuate muscle; *C.M.*, internal arcuate muscle; *T.M.*, trigonal muscle; *A.*, Albarran's gland tubules; *M.L.*, middle lobe of prostate; *L.L.*, lateral lobe of prostate; *S.V.*, seminal vesicle (Embryo, Carnegie Institute 2679, slide 2, section 2);  $\times 15$ .







increase in number until at a point below the lower border of the loop from the internal circular layer where it passes in front of the urethra, they pass across the midline and form a sheath of striated fibers running in a direction generally circular with regard to the urethra, but extending only about half way around it. As one passes downward, however, the fibers pass farther and farther dorsally until at a point opposite the apex of the prostate, they join those from the other side in a raphé, thus forming from this point downward a complete circular sheath about the urethra. This system of striated muscle makes up the external vesical sphincter.

It is clear that at the vesical orifice we are not dealing with a simple sphincter; i. e., a muscle whose origin and insertion is in itself. The muscle fibers comprising the pear-shaped loops about the upper end of the urethra arise from and are closely connected with the longitudinal coat of the bladder, but we do not know whether they contract in unison with it or not. The trigonal muscle exerts its pull in the direction of the open part of this muscular loop, and it undoubtedly acts to pull open or elongate the vesical orifice. The internal sphincter is a surgical designation and not an anatomic entity, the vesical orifice being closed by two loops or arcs, one arising from the internal circular layer, the internal arcuate muscle of the vesical orifice (*musculus arcuatus internus orificiae vesicalis*), and the other from the external longitudinal layer of the bladder wall, the external arcuate muscle of the vesical orifice (*musculus arcuatus externus orificiae vesicalis*).<sup>12</sup>

#### PHYSIOLOGY OF THE TRIGON

A pharmacologic study of the trigon muscle showed that it was innervated by true sympathetic fibers as it contracted on treatment with epinephrin and ergotoxin. No parasympathetic nerve endings were present as there was no response to pilocarpin, physostigmin or atropin. The bladder muscle proper gave reactions to both sympathetic and parasympathetic nerves. The tests with nicotin on the trigonal muscle gave a response indicating the presence of ganglionic structures.

Since pharmacologic and embryologic studies show an origin and nervous control different from those for the rest of the bladder, it is quite reasonable to suppose that its contraction and relaxation occur independently of those of the rest of the bladder.

A cystoscopic study of the mechanism of urination was made on a large series of patients. With the cystoscope in position, the bladder was filled to capacity with water and the patient alternately urged to strain (as for voiding urine) and then to relax. While the patient is straining, a cystoscope can be drawn down into the posterior urethra just as in a tabetic bladder. The vesical orifice, when dilated while

making an attempt to void, is not circular but is pear-shaped. This shape is undoubtedly due to the contraction of the trigonal muscle and the synchronous relaxation of the two loops of muscle about the orifice. The movement is slight and slow on the ventral aspect as the orifice dilates, but on the dorsal side the trigonal muscle accelerates and augments the relaxation of the small loop. The contraction of the trigonal muscle is powerful as shown by the depression of the floor of the urethral orifice and the marked upward movement of the verumontanum. The striae anterior to the verumontanum are apparently fixed at the lower ends, but the verumontanum moves upward with straining, and in some cases appears as if a little greater effort would cause it to enter the bladder proper. The plica ureterica remains approximately fixed throughout.

The part played by the trigon in the opening of the vesical orifice was then studied from the inside of the bladder. Cases of suprapubic cystotomies were used. The cystoscope was passed through the small fistula and the bladder filled with water. Then as the patient strained, the trigon was seen to contract as previously described, the vesical orifice opened, and normal voiding followed.

Through an endoscope the opening and closing of the vesical orifice were studied from the urethral side (Fig. 7). The instrument was passed into the bladder and was slowly withdrawn. The dorsal lip of the vesical orifice appeared first as a semicircle and then as an isosceles triangle with collapsing sides. Just before closure was complete, the patient attempted to void and there was a sluggish lateral movement outward of the sides and a quick downward pull of the base or trigonal muscle. The endoscope was then slowly withdrawn and the sides of the triangle collapsed, giving the appearance of an inverted letter "Y". This is doubtless due to the action of the trigonal muscle and of the oblique arcuate muscle of the internal "sphincter" previously described.

#### CHANGES IN THE TRIGON, SECONDARY TO RENAL TUBERCULOSIS, AND THE SURGICAL TREATMENT

Some of the pathologic changes that take place about the trigonal end of the ureter in cases of renal tuberculosis have been reported by one of us,<sup>16</sup> the salient points of which will be reiterated here.

In cases of renal tuberculosis there is generally a marked distortion of the trigon owing to traction of a shortened tuberculous ureter, the ureteral orifice of the good side occupying a position near the midline,

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16. Young, H. H.: Changes in the Trigone Due to Tuberculosis of Kidney, Ureter and Bladder. Bridge Formation and Floating Trigone, *Surg., Gynec. & Obst.* **26**:608 (June) 1918.

while the opposite tuberculous ureteral ridge is drawn outward on the bladder wall (Case 8971).

The progressive steps of the invagination of the trigon into the ureteral orifice due to traction by a shortened ureter have been followed in our series. The first step is seen in Case 2438, in which the ureteral orifices lay equally distant from the midline on hypertrophied ridges, the right orifice appearing normal, but the left was a transverse slit lying across the ureteral ridge.

The next step is the invagination of the ureteral ridge into this transverse slit as is shown in Case 5541. Here the trigon is markedly distorted, the left ureteral orifice occupying a position almost in the midline while the right orifice is not visible, the corner of the trigon



Fig. 8.—A shortened tuberculous ureter causes the corner of the trigon to stand out as a wedge, which disappears under a crescent-like fold of mucosa. With each inspiration a stream of pus is seen to come from under this fold (Case 5541).

being drawn upward and outward with a pronounced thickening of the ureteral ridge which disappears under a crescent-shaped fold of mucosa with pouches on each side. With each inspiration a stream of pus is seen to come from under this fold of mucosa (Fig. 8).

In Case 3890, starting from the normal right ureteral orifice and passing toward the left, the ligamentum interuretericum becomes progressively more and more pronounced and is finally greatly elevated, the whole corner of the trigon standing out as a wedge-shaped ridge of considerable prominence running into the left ureteral orifice. As the patient expires, the corner of the trigon is drawn up into the ureter.

and as he inspires, it descends at least 1 cm., but even on deep inspiration the ureteral orifice is still invaginated. As the patient lies on his back the prominent trigonal ridge slides back and forth in the ureteral orifice synchronously with the respiration. On inspiration, the diaphragm descends, and along with it the kidney and shortened tuberculous ureter; and vice versa, on expiration the ureter draws the trigon up in this remarkable case, the first on record. The ureteral orifice is held up as a prominent concave fold upon this ridge, in front of and behind which is quite a deep pouch, probably 2 cm. deep. Following a left nephrectomy the cystoscopic picture was markedly changed. The left ureteral orifice lay on a hypertrophied ridge which was much less prominent than before, the orifice appeared a little more contracted than normal, and there was no urine coming from it. There was no movement of this corner of the trigon on respiration and no invagination.

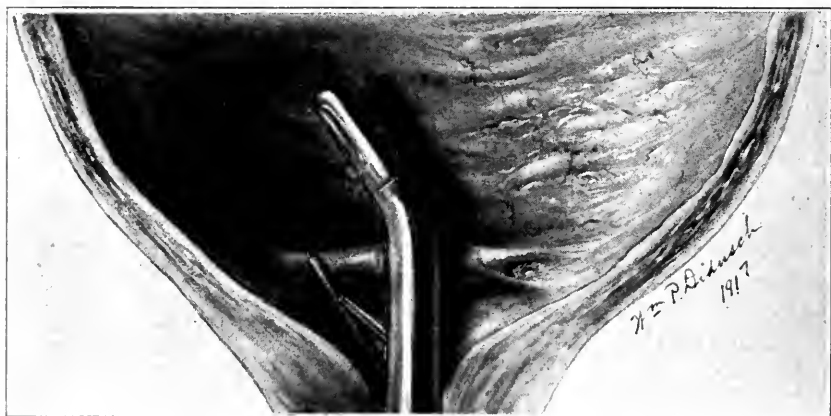


Fig. 9.—The trigon is elevated above the surrounding bladder mucosa like a suspension bridge, supported only at the three corners. The cystoscope is in position, with fulgurating wire separating points of attachment of trigon (Case 3565).

A later stage is the ulceration of the depressed portions of the bladder leading to the complete undermining of the elevated trigon which thus forms a bridge of healthy tissue across the newly formed tuberculous cavity. In Case 5194, following a right nephrectomy, there was no relief from vesical symptoms, the bridge causing an obstruction to urination, vesical pain, frequency of urination (voiding every ten to fifteen minutes) with marked burning in the bladder. Eight months later, through a suprapubic incision the right half of the bridge was removed with an electric cauter, the left half not being disturbed. Though a marked vesical tuberculosis was present, there was a tempo-



rary improvement of symptoms. (Five years later the patient reported that he was still able to carry on his business, and had gained 40 pounds in weight, but had complete incontinence.)

In a similar case (Case 3565) the entire trigon was found by cystoscopy to be detached, except at its three corners, and floating (Fig. 9). It was removed, the attachments at the three corners being destroyed with a rongeur cystoscope and fulguration, and a week later the trigon, which was free in the bladder, was removed with forceps through a cysto-urethroscope. The patient's condition was distinctly improved as micturition was less difficult and frequent, but he had a small amount of residual urine and complained that he had to strain to pass the last urine. (He died of pulmonary tuberculosis two years later.)

No similar cases have been recorded in the literature since (or before) our publication, but it seems very evident that tuberculosis may produce not only marked thickening but also shortening of the ureter, and that this in turn may make traction upon the vesical end of the ureter and trigon, leading to invagination of the margin of the ureteral orifice and elevation of the trigon on that side; leaving the bladder depressed around it. Tubercle bacilli coming from the ureter naturally find easy lodgment in these vesical pouches, while the greatly elevated ureteral ridge and trigon remain uninvolved. Ulceration in the pouches may lead to undermining of the trigon and separation from the bladder.

It is interesting to note the changes in micturition which have occurred as a result of these transformations of the trigon. Urination is apparently normal as long as the trigon is not detached, but when the trigon becomes pathologically dissected free from the bladder muscle, micturition seems to become less free and residual urine is present. In one case this persisted after operative removal of the "floating trigon." Was this abnormality of micturition due to the absence of the trigon and consequent lack of muscle to open the vesical orifice and provide free urination? We think so.

#### TRIGONAL CHANGE FOLLOWING NEPHRECTOMY

The changes in the trigon following nephrectomy, when there is not a shortened tuberculous ureter, are shown in Case 3597. The trigon was normal preceding a right nephrectomy for tuberculosis, but two years later the right ureteral orifice was retracted, round and gaping, and was pulled over by the function of the other ureter, as the contraction of the trigon undoubtedly extended up to the orifice of the right side, and the swirl of urine from the left swept over it and appeared to come from it.

## TRIGONAL OBSTRUCTION SIMULATING HYPERTROPHY OF PROSTATE

The part played by the trigon in the process of micturition was first suggested to one of us (Young) in 1900 by a study of Specimen 4355 in the museum of the Royal College of Surgeons (London).<sup>17</sup> Later while using an irrigating cystoscope with a free flow of water, it was noticed that the straining of the patient caused the vesical orifice to open and the verumontanum to be pulled violently upward.

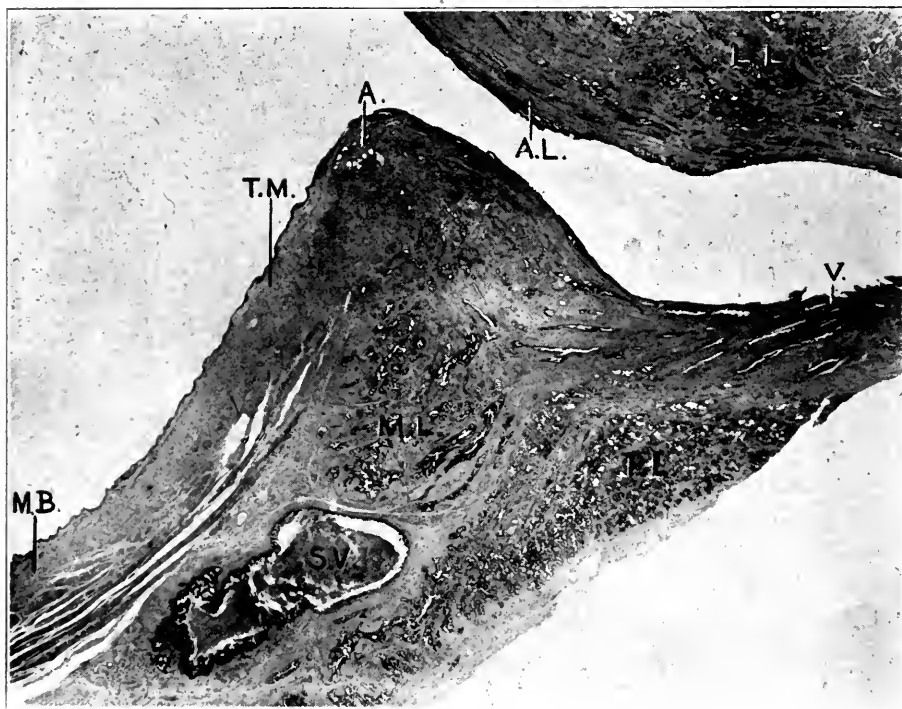


Fig. 10.—Sagittal section through vesical orifice of a man, aged 43, showing an early median bar: *MB*, Mercier's bar; *T.M.*, trigonal muscle; *SV*, seminal vesicle; *V.*, verumontanum; *PL*, posterior lobe of prostate; *ML*, middle lobe of prostate; *A.*, Albarran's gland; *LL*, lateral lobe of prostate; *AL*, anterior lobe of prostate (Specimen, Carnegie Institute 2911, slide 6);  $\times 3.8$ .

As we have demonstrated now in many cases, and have explained in the section on anatomy, the trigon plays an active part in the process of micturition, one of its functions being to pull open mechanically the

17. Descriptive Catalogue of Pathological Specimens (Paget), London 4:316, 1885.

vesical orifice. With the formation of an obstruction at the orifice,<sup>18</sup> one would expect to find a compensatory hypertrophy of the trigon (Figs. 10, 11 and 12). Our studies show this to be the case and also that following the removal of this obstruction there is a corresponding atrophy or diminution of the hypertrophied trigon. Part of the irritability of the bladder, frequent urination and spasm at the end of urination undoubtedly is due to this hypertrophy. Occasionally, an enlarged trigon is associated with a hypertrophy of the median portion of the prostate and may form one firm elevated mass in conjunction with it, the two together acting as an obstruction to urination. The fact

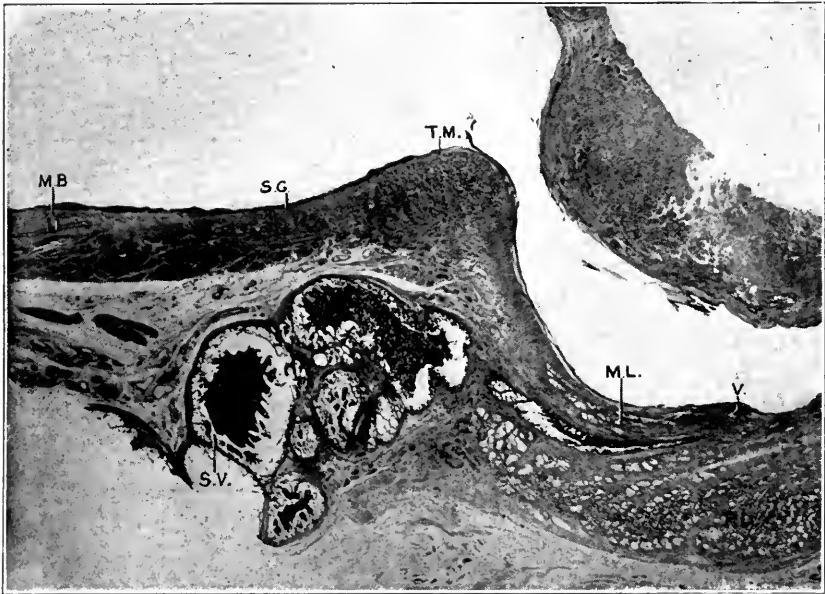


Fig. 11.—Sagittal section through vesical orifice of a man, aged 59, showing a median bar: *TM*, trigonal muscle; *SV*, seminal vesicle; *V*, verumontanum; *PL*, posterior lobe of prostate; *ML*, middle lobe of prostate; *LL*, lateral lobe of prostate; *MB*, Mercier's bar; *U*, ureter; *SG*, subtrigonal gland (Specimen, Carnegie Institute 2899, slide 5);  $\times 2.4$ .

that trigonal obstruction often simulates hypertrophy of the prostate has been reported by one of us.<sup>19</sup> Patients have come for operation for cure of prostatic obstruction and careful examination discloses that obstruction is not due to the prostate, but to enlargement of

18. Fuller, E.: Chronic Contraction of the Prostatic Fibers Encircling the Vesical Neck and Its Treatment, *Am. J. M. Sc.* **114**:440-448, 1897.

19. Young, H. H.: The Ultimate Results of Prostatectomy, *Mem. & Bull. Int. Ass. Urol.*, London, 1912, p. 116.

the trigon which acts as a great transverse dam in the floor of the bladder behind the vesical orifice, preventing the passage of urine. In cases in which the obstruction has persisted sufficiently long to cause pouch formation back of the hypertrophied trigon or an undermining of the trigon, removal of the barrier will not be sufficient to restore the normal function of the bladder as the trigon acts as a septum shutting off the flow of urine through the prostatic urethra. In such a case this valve-like effect of the undermined trigon must be destroyed.

In a study of the cases of hour-glass bladders reported in the literature,<sup>20</sup> and in our records, we found no instances of an undermined



Fig. 12.—Sagittal section of the bladder of a man, aged 58, showing a median bar with beginning undermining of hypertrophied trigon and marked trabeculation and cellule formation. The dilated posterior urethra was due to a stricture.

trigon taking part in the formation of the ring of contracture. In all cases, Mercier's bar was definitely in one cavity or the other. However, in cases of double bladders or diverticula, in which the ureteral orifices

20. Caulk, J. R.: Hour-Glass Bladder; Remarks on the Resection of the Base of the Bladder for Transverse Septa. *Ann. Surg.* **71**:22-27 (Jan.) 1920. Fuller, E.: Anteroposterior Subdivision of the Bladder; an Important Anomaly, *J. Cutan. & Genito-Urin. Dis.* **18**:531-536, 1900. Pagenstecker, E.: Ueber Entstehung und Behandlung der angeborenen Blasendivertikel und Doppelblasen, *Arch. f. klin. Chir.* **74**:186-231, 1904.

are in separate cavities, Bell's muscles are always present, but Mercier's bar may be missing.<sup>21</sup>

A study of twenty necropsy specimens of hypertrophied trigons, obtained from patients with vesical obstruction, who had been cystoscoped but not operated upon, showed that trigonal hypertrophy is most marked in cases of elevation of the dorsal portion of the vesical orifice, "median portion,"<sup>22</sup> particularly in cases of enlargement of Albarran's group of subcervical glands (Fig. 13). When the lobe is eccentrically located, the hypertrophy tends to be asymmetrical, being



Fig. 13.—Sagittal section of bladder of man, aged 65, showing an Albarran's lobe. There is a marked hypertrophy of the tubules beneath the vesical orifice and the hypertrophied trigon is dissected away from the bladder wall.

greatest on the side of the most dependent part of the vesical orifice, but when the lobe is in the center, acting as a ball valve, the hypertrophy

21. Cathelin, F.: The Auscultation of the Kidney, *Urol. & Cutan. Rev.* **23**:403-408, 1919. Hinman, F.: The Etiology of Vesical Diverticulum, *J. Urol.* **3**:207-246 (Aug.) 1919. Krogus, A.: A Discussion of Congenital Diverticula of the Bladder: Their Management, *Urol. & Cutan. Rev.* **21**:606-611, 1917. Young, H. H.: The Operative Treatment of Vesical Diverticula, with Report of Four Cases, *Johns Hopkins Hosp. Rep.* **13**:402-446, 1906.

22. Home, E.: An Account of a Small Lobe of the Human Prostate Gland, Which Has Not Before Been Taken Notice of by Anatomists, *Phil. Tr. Roy. Soc. London* **96**:195-204, 1806.

is symmetrical. The fibers passing over the center are not so heavy as a rule as those at the edges, Bell's muscles being enormously hypertrophied and tending to pass around the lobe, giving it a mushroom-like appearance. However, if one or both of Bell's muscles pass over the lobe, there is a bipartite or tripartite hypertrophy formed.

A study of 125 cases of hypertrophied trigon has shown that in most of the cases the hypertrophy partially or wholly compensates for the obstruction. A cystoscopic study of the vesical trigon shows a series of characteristic stages in the development of its hypertrophy. At first the trigon is very slightly elevated above the bladder wall, the ureteral ridges being definitely raised. In the next stage the trigon is elevated and on a level with the ureteral ridges and ligamentum interuretericum, behind which is a shallow cavity. With the formation of a median bar at the posterior part of the vesical orifice the trigon lies close against it as a shelf. The interureteric ridge may stand out as a cord so there is a slight pouch in front of it on the trigon and a deeper bas fond behind. With advancing hypertrophy the bas fond becomes deeper, and eventually undermining takes place, the trigon being dissected free from the bladder wall. The trigon then stands up as a ledge or dam, dividing the bladder in two parts and giving it an hour-glass appearance. The dissection beneath the trigon may be carried down as far as the posterior urethra with the formation of a diverticulum holding from 250 to 300 c.c.

Cystoscopic appearances are not to be relied upon if the patient is straining while being examined, for under those conditions the trigon may stand up very high and apparently be the cause of the vesical obstruction when there is really very little hypertrophy. In one of our cases (Case 4088), the trigon stood out as such a prominent bar at cystoscopy that it was planned to divide it when the bladder was opened, for a diverticulectomy. At operation, however, the trigon appeared normal, a true hypertrophy not being present.

#### SURGERY OF HYPERTROPHIED TRIGONS

We can find no literature or reported cases on the surgery of the hypertrophied trigon; but in our own work we have attacked them in several ways, namely, by intra-urethral, perineal and suprapubic routes.

In cases of fairly small hypertrophies, the trigon and median bar can be caught with the punch<sup>23</sup> and excised together. The instrument is introduced far into the bladder, the cutting obturator withdrawn an

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23. Young, H. H.: A New Procedure (Punch Operation) for Small Bars and Contracture of the Prostatic Orifice, *J. A. M. A.* **60**:253-257 (Jan. 25) 1913.

inch, and the instrument drawn out until the trigon is caught in the fenestra. The instrument is then still further withdrawn, drawing the trigon well up against the median portion of the prostate, which is also finally caught in the fenestra. The inner cutting tube of the instrument is then pushed home and with slender alligator forceps the excised mass, consisting of trigonal muscle and prostatic bar, is removed. Additional cuts may be made, if desired, at the prostatic orifice.

For hypertrophies too great to be caught by the punch, one of us (Young) has devised a "cystoscopic trigonotome" (Fig. 14). This instrument resembles a cystoscopic lithotrite with a sharp knife set in the posterior surface of the male blade. The instrument is passed into the bladder, closed, the straight cystoscope pushed inward, rotated while the blades remain up, and a view of the trigon obtained. The blades of the instrument are then opened out, turned downward, and

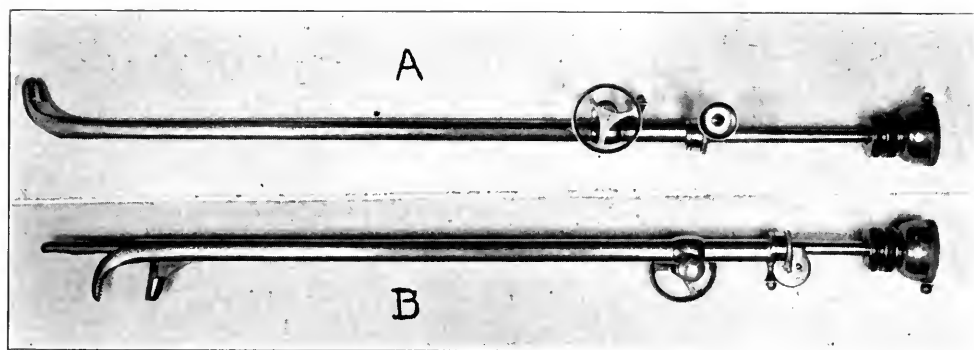


Fig. 14.—*A*, trigonotome, closed, with observation cystoscope in position for introduction into the bladder; *B*, trigonotome, opened, showing the cutting edge of the posterior blade, and rotated in position to cut the trigon under cystoscopic vision.

placed in position to grasp the trigon, the whole procedure being directed through the cystoscope. By turning the external screw, the blades are approximated and the trigon divided by the razor blade knife. This instrument can be used through the urethra or through a perineal incision.

The operation of choice in the case of large hypertrophies is a suprapubic cystostomy and the splitting of the trigon. Hemorrhage is controlled by sewing the cut edges with a continuous suture of chromicized catgut.

The appended brief case reports illustrate the various operations.

CASE 1 (No. 2749).—*Division of trigon by the punch*.—Dr. J. A. J., aged 50, admitted Dec. 15, 1910, complained of urgency of urination of two years' duration. Recently he had had dribbling after urination. He voided urine every

three hours during the day and twice at night. The patient said there was no hesitation, urine flowing with considerable force and in a fairly good stream. His only complaint was that when the desire to urinate came, it was extremely urgent, so much so that he was unable to control it. This occurred generally when from 4 to 6 ounces of urine had accumulated. Urination afforded immediate relief until the bladder filled up and urgency again came on.

*Examination.*—Cystoscopic examination revealed: residual urine, 15 c.c.; bladder capacity, 340 c.c. There was a slight elevation of the median portion of the prostate in the shape of a small bar. The trigon itself was markedly elevated, the ligamentum interuretericum being quite prominent, with a fairly deep pouch behind it. Both ureteral ridges were moderately hypertrophied. With finger in the rectum and cystoscope in the urethra, the trigon felt thickened.

*Operation and Results.*—Dec. 19, 1910, operation was performed with local 4 per cent cocain anesthesia. The trigon and median bar were caught in the punch and excised together; a piece of tissue 7 mm. in diameter and 2 cm. long which seemed to be composed of the median portion of the trigon and the median bar with a small intervening sulcus, was removed. A two-way retained catheter was inserted. Convalescence was uneventful and the patient was discharged in one week, in good condition.

May 20, 1912, a letter stated: "Void naturally every three hours during day, once at night, 7 ounces at a time."

March, 1915, another letter stated: "I am in perfect health and working."

October, 1920, a letter said: "I have no bladder trouble."

*Comment.*—In this case, the obstruction due to a median bar and a hypertrophied trigon was removed intra-urethrally with a punch, and the patient has remained free of symptoms for more than ten years.

*CASE 2 (No. 2652).*—*Division of trigon by means of trigonotome, through urethra.*—J. F. R., aged 72, admitted Sept. 29, 1910, complained of complete retention of urine. He was leading a catheter life. He had had urinary trouble for about twenty years and had had numerous operations in London, including a suprapubic prostatectomy and a suprapubic cystotomy to dilate the internal prostatic orifice, and a perineal section for the same purpose. None of the operations removed the obstruction, and the patient found it necessary to continue to use a catheter several times daily. The history otherwise was not of interest.

*Examination.*—Cystoscopic study of the prostatic orifice revealed no enlargement anteriorly or on either side. Posteriorly, it was impossible to see the prostatic margin owing to a very greatly elevated and hypertrophied trigon which projected far anteriorly and lay close behind the prostatic orifice with a deep pouch behind it. Both ureteral ridges were very prominent, and from them extended outward and forward on each side a septum-like ring of contraction which must have given the bladder an hour-glass character. There were no diverticula and no other septums. The ureteral orifices were pinhead in size and lay quite close together on the summit of the elevated trigon. The patient refused to have another suprapubic cystotomy performed; and owing to the position of the ureteral orifices, excision of a portion of the trigon with the punch seemed to be contraindicated by the possibility of injuring the ureters. An instrument was therefore devised to cut through the trigon under cystoscopic direction. This instrument was christened a "trigonotome."





Fig. 15.—Cystoscopic appearance of hypertrophied trigon (Case 6).



*Operation and Results.*—Oct. 8, 1910, under local 4 per cent. cocain anesthesia the trigonotome was successfully passed into the bladder, the trigon engaged and thoroughly cut in the median line by means of the sharp knife on the posterior surface of the male blade. The trigon was very fibrous. There was considerable resistance, but the division was easily accomplished. The patient was allowed to try to void immediately afterward and urinated freely; he remarked at once that urination was very much more free than before.



Fig. 16.—The first stage of the operation, showing the bladder opened and exposing the hypertrophied trigon and bas fond.

The patient had an uninterrupted convalescence and was discharged from the hospital in a week, Oct. 15, 1910. He voided freely without difficulty or pain, bladder capacity 700 c.c. and residual urine 10 c.c.

March 1, 1911, he reported: "Facility for urination still improving; better health now than for past seventeen years."

He died in January, 1921. His physician stated that he used a catheter only occasionally during the last nine years, and daily during the last year when the residual urine varied from 4 to 8 ounces. He voided twice at night and five times during the day. His general health was quite good up to the time of his death of "cerebritis" at the age of 83.

*Comment.*—This patient was an invalid leading a catheter life, because of a retention of urine due to an enormously hypertrophied trigon that stood up as a ledge, and had been overlooked at previous cystotomies. He refused to undergo any but an intra-urethral operation, and because of the juxtaposition of the ureteral orifices, the punch could not be used for fear of cutting a ureter, hence the trigonotomy was devised. For the following ten years he was practically well, but during the last year of his life (at age of 83), he used a catheter daily.

CASE 3 (No. 4885).—*Division of trigon by trigonotomy through perineal incision.*—S. R. D., aged 48, admitted Feb. 10, 1916, complained of difficulty in emptying the bladder and a postoperative sinus. Nine months before he had a sudden onset of frequency with marked terminal dribbling. On the third day, he consulted a physician who washed out the bladder, using a large syringe with considerable force. This caused much pain and was followed by complete retention. A month later a suprapubic prostatectomy was performed, and the fistula remained open, though there had been considerable intra-urethral treatment. During the last three weeks he had been catheterized daily because of a constant residual of 12 ounces. His history was otherwise unimportant. The general physical examination revealed nothing of importance.

*Examination.*—Cystoscopy revealed: residual urine, 400 c.c.; bladder capacity, 750 c.c. In the median line posteriorly, there was a deep cleft between the two rounded lateral masses and immediately behind and almost drawn up against the orifice was an hypertrophied trigon. The right ureteral ridge extended far outward as a very prominent ridge and became more and more enlarged as the ureteral orifice was approached. The ligamentum interuretericum was concave, much hypertrophied and elevated, and lay immediately behind the median portion of the prostate, with a pouch behind it. The left ureteral ridge was less prominent than the right.

*Operation and Results.*—Feb. 14, 1916, under nitrous oxid, oxygen and ether anesthesia the hypertrophied trigon and contracted vesical neck were divided through the perineum. The usual exposure was made and the prostatic orifice was found to be a small, circular, cicatricial opening which, until it was dilated by pressure, would not admit the tip of the finger. The median portion of the trigon was elevated and was incorporated with the median portion of the prostate in a firm, fibrous mass, which seemed undoubtedly to be the cause of the obstruction. The ureteral ridges were elevated and hypertrophied, being about the size of the small finger. The trigon was then caught and divided with the trigonotomy, and then with a knife passed along by the side of the finger, quite a deep incision was made, definitely dividing the trigon for a distance of about 7 or 8 mm., after which a cleftlike depression in the trigon was easily made out, the bottom of the cut being apparently on a level with the pouch behind the trigon.

*Subsequent Course.*—March 9, 1916, cystoscopy was performed following dilatation with filiforms and followers of a slight stricture in the membranous urethra. There was no residual urine. There was a wide concavity in the trigon on a level with the floor of the bladder back of the trigon, while on

each side of this furrow the two corners of the trigon were quite elevated. It was possible to draw the cystoscope out and see the posterior urethra with ease.

March 31, 1916, a note states: "Patient discharged; suprapubic fistula is healed; he holds his urine five or six hours during the day and goes all night without voiding. At times his stream is quite large; at other, stream is small."

Dec. 19, 1916, the patient reported that his general health was good; the stream had no force.

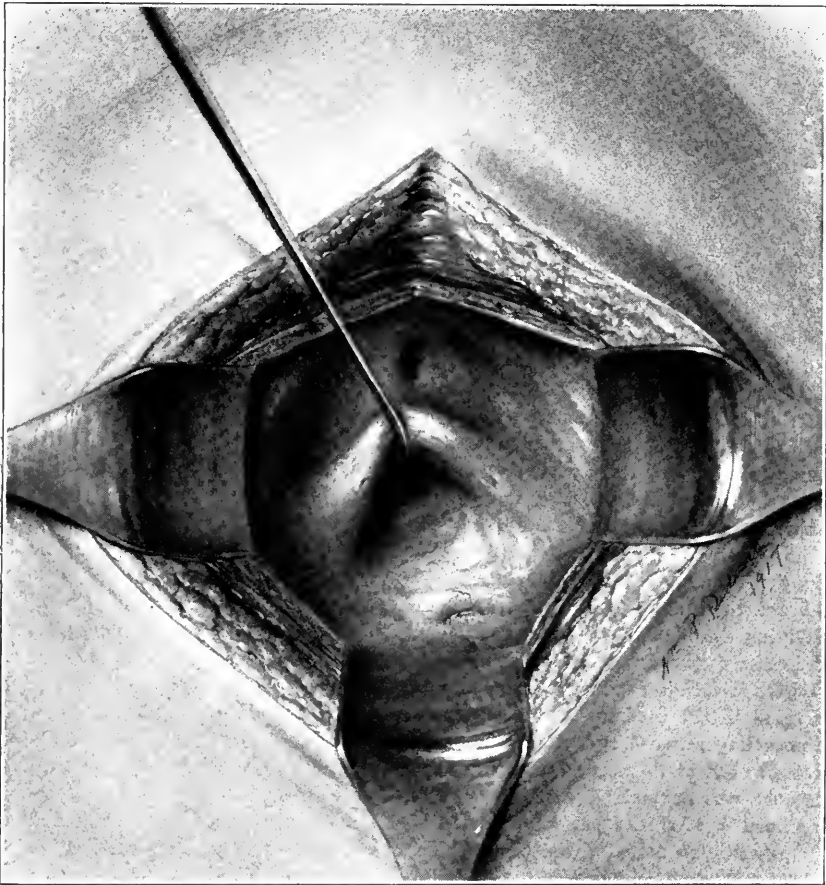


Fig. 17.—The hypertrophied trigon is lifted up showing the extent of the pouch beneath it.

March 5, 1921, the family physician in a letter stated that the patient's general health was very good; that he was able to empty the bladder fairly well, but it took from five to ten minutes, the stream being very small.

*Comment.*—A suprapubic prostatectomy had not removed the entire obstruction, as an hypertrophied trigon remained which caused a residual of 12 ounces of urine (and an unhealed fistula) and necessitated daily catheterization.

Because of the suprapubic scar, a perineal section was performed, and the trigon divided with the trigonotome and a scalpel. All obstruction was thus destroyed, and the patient has been free from the use of a catheter for five years.

CASE 4 (No. 649).—*Division of the trigon through a suprapubic cystotomy.*—L. M., aged 68, admitted June 16, 1904, complained of frequent urination of four years' duration. Six months before admission he was catheterized for the first time, and 1,000 c.c. of residual urine removed, since which time he has been catheterizing himself twice daily. Between times he voids frequently and with difficulty.

*Examination.*—Cystoscopy revealed residual urine, 680 c.c. The cystoscope was introduced with ease, but a large mass was encountered after entering the bladder, requiring considerable depression of the handle. In the base there was an extensive growth which was thought to be a tumor and which seemed almost to fill the base of the bladder. On the left side the tumor extended far up from the base and the surface was irregular but not villous in character, very red and globular in shape and not ulcerated. It was thought to be malignant and inoperable. The patient was advised to use a catheter three times a day.

April 30, 1906, the patient returned in fairly good health after two years' absence, complaining of having to use a catheter several times daily. Cystoscopy showed a stone in the bladder, and a study of the supposed tumor at the base of the bladder demonstrated that it was not a tumor but a marked elevation of the trigon, associated with very little hypertrophy of the prostate.

May 1, 1906, under ether anesthesia lithotomy and division of the trigon through a suprapubic incision was performed, and the calculus removed. The lateral lobes of the prostate were not at all enlarged; there was a very small, thin, transverse median prostatic bar elevated not more than 1 cm. and not more than 5 mm. thick. The prostatic orifice felt soft and was easily distensible. In the region of the interureteral ligament was a broad, transverse septum, 1.5 cm. thick and elevated at least 4 cm. above the normal level of the trigon, dividing the bladder into two compartments. The anterior surface of the ridge lay close to the prostatic orifice and apparently acted as an obstruction. Several large vesical diverticula were present. The trigonal septum was completely divided in the median line, a wedge-shaped section being removed. Owing to hemorrhage, two large clamps were left on the cut edges, the handles being brought out of the wound and the bladder closed loosely around them. Convalescence was normal.

April 6, 1908, the patient reported that he was entirely cured; voided urine freely at intervals of three hours. He was catheterized and no residual urine was found.

*Comment.*—This patient was forced to lead a catheter life, because of the obstruction from a ledge-like hypertrophied trigon. The obstruction was removed by taking out a wedge from the trigon through a suprapubic incision. At the end of two years, when last heard from, he was entirely well.

CASE 5 (No. 2133).—L. P., aged 44, admitted April 3, 1909, complained of hesitancy and a small stream, having "to wait and apparently syphon off the urine." Fifteen years before he had an attack of frequency and urgency and again one year before admission. At this time he had an "extreme fulness in the stomach, thought to be flatulence," but when he was catheterized, 32 ounces of urine was removed. He then realized that his stomach trouble of the last year had been due to an incompletely emptied bladder and not indigestion, for

which he had been treated. During the warm weather he used a catheter three times daily, and in the winter five times. Practically no urine could be voided unless there was 12 or more ounces present and even then only an ounce or so, except after intercourse when 5 or 6 ounces might be voided.

*Examination.*—Rectal examination revealed the prostate to be about normal in size, uniform in consistency, slightly firmer than normal but elastic. There were no nodules or induration. The seminal vesicles were a little thickened and adherent, not markedly abnormal. There was no intravesicular plateau

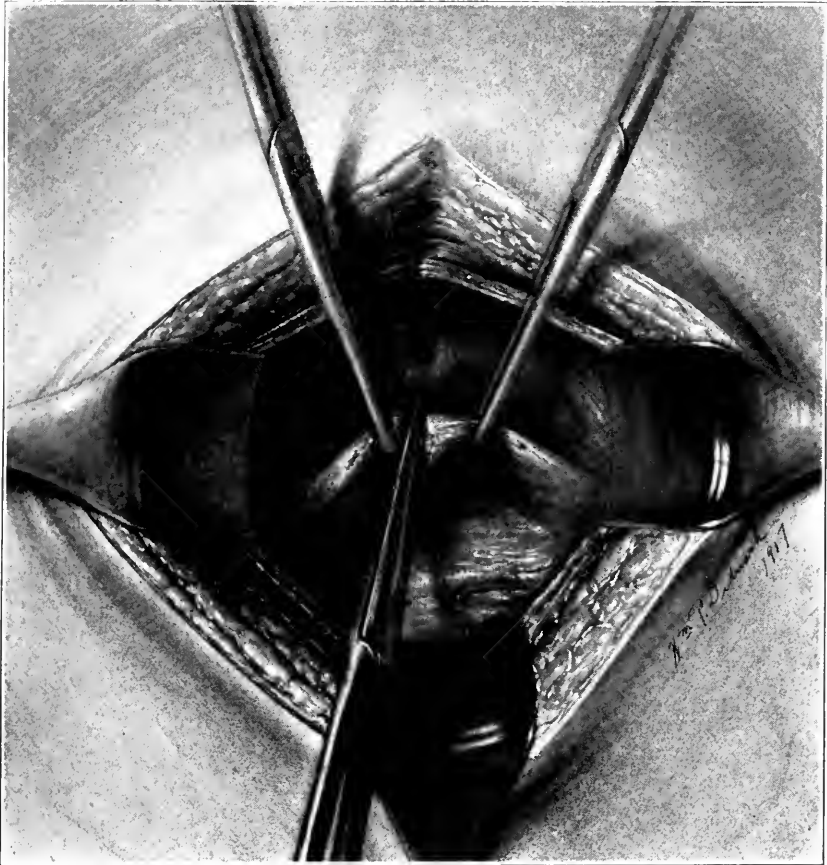


Fig 18.—Dividing the trigon with scissors.

of induration. The bladder above felt a little firmer than normal. The prostatic secretion contained many pus cells and the urine contained bacilli.

*Treatment and Results.*—Cystoscopic examination showed the presence of a median bar, and during the following two months five rongeur and punch operations were performed with the idea of removing more and more tissue from around the vesical orifice. At one time an attempt was made to catch the trigon in the punch, and subsequent cystoscopic examination showed that

this had been successful in dividing a small part of the posterior part of the trigon, but did not divide the trigon near the prostatic orifice where it was causing obstruction. The final operation was suprapubic division of the trigon in the median line including the median portion of the prostate down into the urethra.

After the first operation, a residual of 260 c.c. was found and a bladder capacity of 890 c.c. on forced distention. This was ejected well with considerable force at first, the latter part, however, coming away with very little force. It seems probable that the vesical tonicity was poor.

The tissue (from bar) removed at the first operation was primarily well organized fibrous tissue, at one place there being a few dilated glandular acini, about which there was a mild grade of prostatitis; whereas, the tissue from the second operation (lobules from anterior prostatic margin) contained numerous glands, the whole picture being that of a chronic suppurative prostatitis with glandular hypertrophic changes. The obstruction seemed to be due to glandular rather than fibrous changes.

May 4, 1909, endoscopic and cystoscopic examinations revealed a pronounced bar in the median portion of the prostate, without any evidence of enlargement of the lateral lobes.

May 5, 1909, under ether anesthesia, the median bar of the prostate was excised. Four posterior cuts were made and one anterior.

June 19, 1909, the general result of the operation was that the patient voided throughout the day without the use of a catheter, but always used the catheter at bedtime and found anywhere from 6 to 15 ounces of residual urine. On arising in the morning, urination was much freer than at other times in the day, but always required several attempts to empty the bladder before he had completed the act. He generally voided from 12 to 16 ounces in five attempts.

June 25, 1909, under ether anesthesia, a portion of the lateral lobes of the prostate was excised with the rongeur cystoscope and punch. A small globular piece measuring 1 cm. in diameter was removed from the right lateral lobe with the rongeur. No more tissue could be obtained, so the punch was introduced and several small bits of tissue removed from the region of the right anterolateral aspect, also from the left and a good sized piece from the anterior margin of the prostatic orifice.

May 7, 1910, cystoscopy revealed: residual urine, 340; bladder capacity, 500. The trigon was markedly hypertrophied.

May 12, 1910, under nitrous oxid anesthesia an attempt was made to divide the trigon with the punch. The operation was not very successful as it was impossible to retain the posterior border of the trigon in the grasp of the instrument. Small bits of tissue were removed, there was a very small amount of hemorrhage, and a retained two-way catheter was passed in the urethra and continuous irrigation kept up for several days.

May 23, 1910, under nitrous oxid, oxygen and ether anesthesia, a suprapubic cystotomy and division of the hypertrophied trigon was performed. There was no obstruction in the region of the prostate, the prostatic orifice being dilated and no lobules or masses were around it or within the urethra. The trigon was considerably hypertrophied and stood up as a plateau. Just behind the vesical orifice was a small transverse ridge in the trigon elevated about 4 mm. Back of this there was an irregular deep notch in the trigon showing conclusively that the punch had divided the trigon and removed tissue almost up to the prostatic orifice. It seemed probable that the elevated ridge in the anterior portion was acting as an obstruction, so it was divided with



scissors and scalpel. A study of the rest of the bladder showed a very flabby condition of the bladder wall which instead of contracting as usual, fell together in folds. No deep diverticula were seen, though there were one or two small shallow pouches between oval flabby trabeculations. Convalescence was satisfactory and the suprapubic fistula closed promptly.

October, 1910, it was reported that the patient voided six times during the day and once at night; the largest voiding consisting of 12 ounces; and that he did not use a catheter.

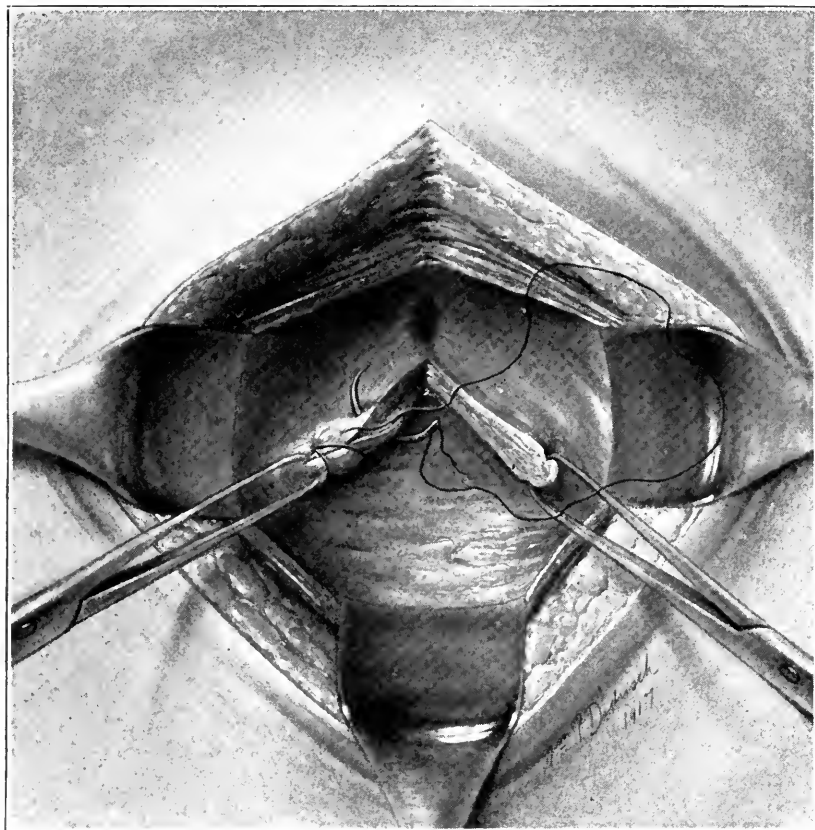


Fig. 19.—Suturing the edges of the split trigon to control hemorrhage.

Jan. 31, 1911, a letter stated: "A catheter was passed and found 5 ounces of residual urine. When the bladder gets very full, I void with a strong stream which gradually dies down to the dimension of a thread."

May, 1912, a letter stated: "I am fine and going strong."

March, 1915, the patient wrote that he had from 8 to 9 ounces of residual urine and used a catheter every few days as a precaution to prevent increase of the residual.

Oct. 3, 1916, by letter he reported: "All functions are entirely normal; the urine is perfectly clear, but the residual urine has increased to 12 ounces. Use catheter morning and night for comfort."

Aug. 17, 1919, by letter he reported: "There is no irritation or discomfort, but 360 c.c. is the irreducible minimum of residual, so I use a catheter.

*Comment.*—It is evident that in spite of the various punch operations, as well as the suprapubic division of the trigon, his obstruction has not been relieved; possibly he may have an obstruction anterior to the verumontanum, similar to the valves seen in children, that is causing his continued retention, but as yet we have not been able to get him to return for cystoscopy to determine whether there is an obstruction, or a paralysis of the bladder.

CASE 6 (No. 5533).—A. O. MacD., aged 43, admitted Nov. 14, 1916, complained of retention of urine which began gradually four years before with frequency, burning on urination, hesitancy and urgency. Nine months before, his family physician found a large residual, and a retention catheter was used for six weeks. Since that time he had been catheterized every six hours. His history was otherwise unimportant except for rheumatism.

*Examination.*—Rectal: The anal sphincter was of good tone, the prostate was no broader than normal; the median furrow and notch were broad. The right lobe was more prominent than normal, slightly indurated and adherent externally, slightly nodular, and not tender. The right seminal vesicle was drawn outward, slightly adherent, not thickened, soft, not distended. The left seminal vesicle was similar to the right, very little adherent, apparently negative. There was very slight intravesicular thickening. The membranous urethra and rectum were negative; there were no enlarged glands.

Nov. 14, 1916, cystoscopy revealed that the patient had complete retention and a bladder capacity of 1,100 c.c. The lateral prostatic lobes were not intravesically hypertrophied but the median portion of the prostate was elevated in the shape of a rounded bar well elevated above the trigon. The trigon was markedly abnormal, being greatly elevated with very prominent ureteral ridges, and the ligamentum interuretericum well raised above the bladder, with a definite pouch behind it (Fig. 15). Examination with the finger in the rectum and the cystoscope in the urethra revealed the median portion of the prostate to be only slightly thicker than normal. The lateral lobes felt a little firmer than normal, and the whole formed a very small collar around the shaft of the instrument.

Nov. 17, 1916, under cocain anesthesia, a punch was passed into the posterior urethra. Four cuts were made: one anterior, one posterior and two lateral for the two halves of the median bar. The anterior cut removed a moderate amount of tissue; the posterior cut removed a large amount of fibrous tissue; the right and left lateral cuts, which were intended to remove the median bar, removed only a small amount of tissue on each side. The hemorrhage was moderate in amount. A large coude catheter, the end of which was covered with kephalin, was introduced and the bladder easily washed clean.

Dec. 23, 1916, cystoscopy showed the same findings as before operation. The symptoms had not been relieved.

Dec. 27, 1916, under nitrous oxid, oxygen and ether anesthesia, a suprapubic cystotomy and division of the trigon was performed (Figs. 16 to 23).

When the bladder was opened and retracted on each side, the trigon dropped backward and was not so prominent as at cystoscopy. The median portion of the prostate was on a level with the trigon, and there was no bar or cicatrix and no obstruction. The finger easily passed a distance of 1 or 2 cm. into the

posterior urethra. The trigon itself was about 8 mm. thick and the transverse septum including the ureteral ridges was about 6 or 7 cm. wide, the ureters being about 4 cm. apart. Both orifices were small and were easily probed. The pouch behind the trigon undermined it completely down to a level of the prostatic orifice from which it was separated by about 5 mm. thickness of muscle and mucous membrane. The trigon was cut through with the scissors in the midline and the two halves immediately retracted on each side. The tissue was not very fibrous. The wound edges were closed over with a continuous

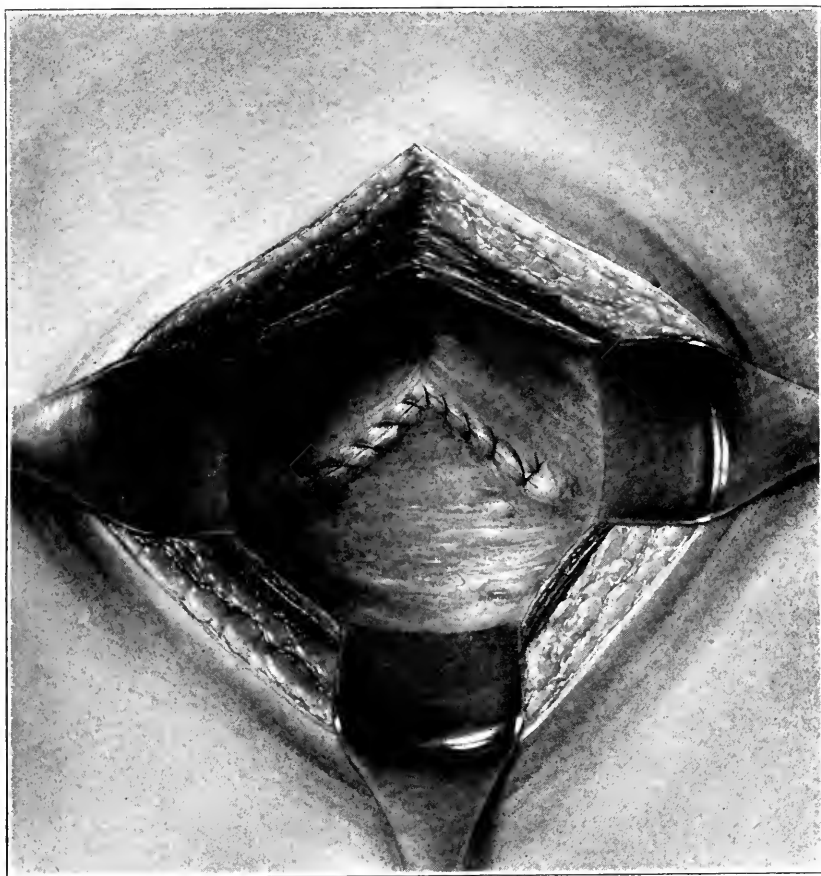


Fig. 20.—Appearance of the base of the bladder at the end of the operation, showing the complete elimination of the subtrigonal pouch.

suture running from the left side across to the extreme right, thus leaving a wide opened V-shaped trigon. The ureteral ridges were relaxed and the orifices were then about 6 cm. apart. Convalescence was uneventful and the suprapubic fistula healed in twenty-three days.

Oct. 16, 1919, the patient reported that he voided four or five times during the day, but could hold his urine for ten hours; he passed 8 ounces at a time, and had 10 ounces of residual.

Nov. 11, 1919, cystoscopy revealed: residual urine, 180 c.c.; bladder capacity, 850 c.c. There was a small rounded lobule anteriorly which projected through the sphincter in the bladder and looked like a definitely hypertrophied lobule. There was a similar smaller lobule on the right. The trigon showed a deep depression between the ureteral ridges. The left ridge was markedly elevated with a pouch behind it. It was thick at the corner of the trigon, but extended far outward to the lateral wall of the bladder. The right ureteral ridge was somewhat thickened and elevated, but not so prominent as the left, and there was no prolongation of the septum outward as in the case of the left. The posterior limit of the trigon was on a level with the bladder and showed a sulcus where it was divided, and this furrow extended down to the median portion of the prostate.

Nov. 18, 1919, the patient returned complaining of frequency and urgency of urination. He had a residual urine of 125 c.c. (infected with colon bacillus) and a bladder capacity of 650 c.c. A punch operation was performed, three cuts being made and 1.5 gm. of tissue removed. The microscopic diagnosis was prostatic hypertrophy, benign, fibrous type, with a chronic infection.

June 25, 1920, under 4 per cent. procain anesthesia in the urethra, a punch operation consisting of eight cuts was performed: (1) right lateral, considerable amount of tissue removed; (2) left lateral, very little tissue removed; (3) median posterior, moderate amount of tissue removed (not nearly so much as usual from median portion); (4) right lateral posterior, moderate amount of tissue removed; (5) left lateral posterior, small amount of tissue obtained; (6) right lateral oblique, fairly large long strip obtained; (7) left lateral oblique, long strip of tissue removed, fairly large; (8) posterior median, small amount of tissue removed. The patient having been operated on several times before and the median portion being very much on a level with the trigon, the prostatic orifice was fairly large, as evidenced by the fact that the amount of tissue obtained from the left lateral margin was small. The posterior median portion was also rather difficult to get and the instrument had to search for it because it was evidently elevated. A test with the instrument, the fenestra being open, showed that there was very little left in any direction to hold the instrument. It seemed evident that all the obstruction was removed.

July 9, 1920, the condition was reported as excellent; residual urine was 10 c.c.

October, 1920, the patient reported that he voided five times during the day, had no nycturia and no pain; he passed 8 ounces at a time, had good control, and had no use for a catheter.

*Comment.*—Five years ago this patient was leading a catheter life due to obstruction from a median bar and an enormously hypertrophied trigon that formed a dam in the bladder. The destruction of the dam by the splitting of the trigon did not effect a complete cure, as some obstruction at the orifice persisted. The removal of this by means of the punch was followed by relief of all symptoms, and a cure.

CASE 7 (No. 5668).—J. H. L., aged 76, admitted Jan. 13, 1917, complained of difficulty in emptying the bladder. This trouble began two months before, when he noticed a mass in his abdomen. His physician catheterized him and removed a "quart" of urine, since which time a retention catheter had been used or interval catheterization. The history was otherwise unimportant.

*Examination.*—Rectal examination: The anal sphincter was of good tone, the prostate was moderately enlarged, not tender, and was freely movable. The

gland was everywhere soft and elastic, there being no areas of marked induration or stony hardness. The right seminal vesicle was indurated and drawn outward; the left was not felt. Physical examination showed nothing else of interest.

Jan. 13, 1917, cystoscopy revealed an hypertrophy of the laterals and median lobe and a remarkably elevated trigon. Both ureteral ridges were very much enlarged with pouches in front and behind them; the ligamentum interuretericum was very prominent with a deep pouch behind it, the bottom of which could not be seen.



Fig. 21.—Beginning closure of the bladder wall.

*Operation and Results.*—Jan. 15, 1917, suprapubic prostatectomy and division of the trigon was performed. The trigon was very prominent and was undermined for at least 1 inch. The distance from the vesical orifice to the edge of the trigon was probably  $1\frac{1}{2}$  inches. The trigon was lifted up, and with the scissors it was split the full length of the bladder pouch beneath it. The edges were sewed with catgut, and the hypertrophied lobes were then removed intra-urethrally. The hemorrhage was small in amount and patient left the table in good condition.

The evening of the day of operation, his temperature rose to 101.4 F. and by January 17 had reached 104.2 F. and signs of lobar pneumonia were present. A blood culture on the day following operation showed a pneumococcus septicemia to be present. The patient died, Jan. 20, 1917, and a necropsy was performed. The salient pathologic findings were: anatomic diagnosis: primary—senility, pulmonary emphysema; (operation: suprapubic prostatectomy) lobar pneumonia; and fibrinopurulent pleurisy (right). Subsidiary—fibrous pleurisy, right hydrocele, right fibrous orchitis; chronic cholecystitis with stones; adenoma

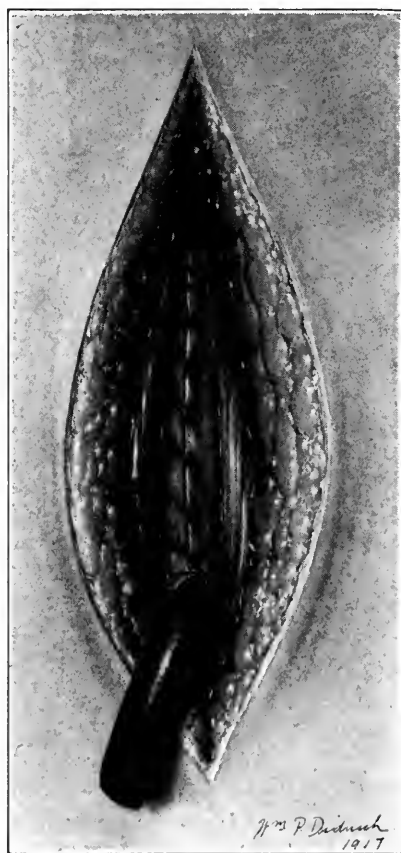


Fig. 22.—Closure of the bladder wall complete, with a drainage tube.

of thyroid, left lobe. Pelvic organs: "On opening the bladder, which is fairly large, it is seen to be filled with an old clot which is definitely adherent in the region where the prostate has been removed. On removal of this clot, one may see a few small rough nodules on the surface. However, there is very little of the glandular tissue left, there being a slight amount in the left lateral lobe. Within the midline of this raw surface after removing the blood clot, there is one small tubule sticking up and when the seminal vesicle beneath is compressed, a creamy whitish looking fluid oozes from the end of this vessel or lobe which stands up in the base of the bladder. On putting a probe in this, it definitely

goes back into the seminal vesicles. There is one very definite nodule within the wall of this mass which measures about 8 or 9 mm. in diameter and is easily hulled away from the tissue surrounding it. It is of whitish color. This small nodule has a definite capsule, and on pressure, it is slightly elastic but very firm. When cut, the surface of the bladder looks rather dense and fibrous and slightly translucent. The mucosa of the bladder wall looks fairly normal, there being only a very slight injection. However, it is fairly thick and

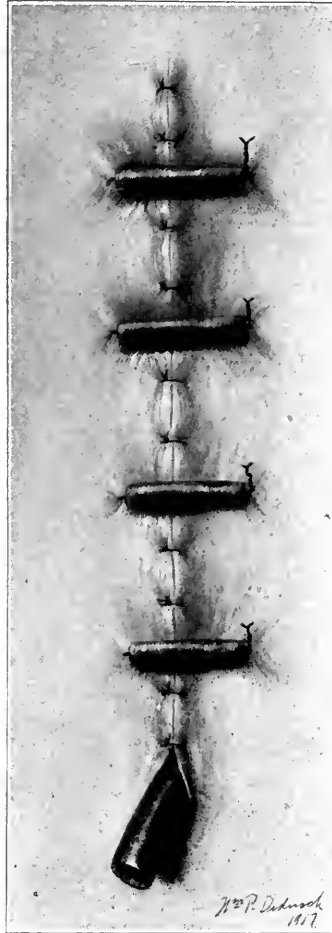


Fig. 23.—Suprapubic incision closed with silver wire tension sutures.

roughened and the individual trabeculae may be easily seen. The seminal vesicles and vas deferens were dissected out but show nothing abnormal. Microscopic section of nodule from prostate showed hyperplasia, no suggestion of malignancy."

CASE 8 (No. 8879).—S. F. L., aged 43, admitted May 21, 1920, complained of frequency, urgency, hesitancy and a residual of from 13 to 14 ounces. The condition had gradually grown worse for the last ten years. He had such a

nauseating odor about him from his urine that he had been obliged to keep practically to himself. A suprapubic prostatectomy was performed two months before admission; the history was otherwise unimportant. The physical examination was negative except for the offensive odor and a general septic condition.

May 26, 1920, at cystoscopy there was found 600 c.c. of extremely foul smelling urine. Just back of the trigon in the midline, there was a diverticulum which extended under the trigon.

*Operation and Results.*—June 7, 1920, under nitrous oxid, oxygen and ether anesthesia, a suprapubic cystotomy with excision of a large diverticulum was performed. The orifice of the diverticulum was about 1 inch in diameter. By inserting a finger into the diverticulum and another into the prostatic orifice it was possible to determine that the diverticulum extended beneath the trigon beyond the internal sphincter. Ureteral catheters were then inserted in each ureter and the trigon was split in the midline, the incision being carried down to the vesical orifice. The sac was freed from underneath the trigon, it being the intention to remove only the side wall and roof, so as to remove the barrier at this point. However, it was found that the sac dissected with surprising ease so the entire thick-walled sac, which must have held from 250 to 300 c.c., was removed. The trigon was then again brought together with interrupted sutures. Convalescence was uneventful and at the time of discharge from the hospital, July 7, 1920, the patient was voiding at normal intervals and had no residual urine.

Feb. 21, 1921, the patient reported that he voids freely without pain, six to eight times a day and holds urine for seven hours at night. He voids from 250 to 300 c.c. at a time and has not used a catheter.

*Comment.*—This case differs from the others in that though the trigon was split, following the removal of the diverticulum, the trigonal edges were again sutured together, thus leaving the muscle in its original condition. Apparently there is a perfect result.

#### COMMENT ON THE SURGERY OF TRIGONAL HYPERTROPHY

An obstruction which prevents the complete emptying of the bladder should be removed. However, when it is due to hypertrophy of the trigonal muscle, the relief must be obtained with as little destruction of the offending part as possible, since this muscle has a very definite and important function—the pulling open of the vesical orifice during micturition. As has been stated, the obstructive trigonal hypertrophies vary in size and form from a shelflike elevation against a median bar to a ledge which forms a dam in the bladder, giving it an hour-glass appearance. Those of the first mentioned type may be removed along with the bar, intra-urethrally by means of the punch. In the more advanced stages, the trigonotome is a more satisfactory instrument, as the cutting can still be done intra-urethrally, but under visual control, and the knife edge is so fine that danger of injuring the ureters can be avoided. The operation of choice, however, is a suprapubic cystotomy and the splitting of the trigonal muscle with a scalpel or scissors. This permits good hemostasis which is very desirable, since the trigon is the most vascular part of the bladder. Furthermore, the



amount of the destruction of the trigon can be better kept at a minimum. The ideal striven for is to restore as far as possible the base of the bladder to its original condition, removing the obstruction and its accompanying pouch, but leaving a maximum amount of uninjured trigonal muscle. The cutting should be done so as to leave uninjured the muscles extending from the ureters to the vesical orifice. Our experience, as shown in the series of cases reported, is that with the removal of all vesical obstructions and the preservation of a maximal amount of the trigon, the untoward symptoms disappear and practically perfect function is restored.

#### SUMMARY

1. The trigonal muscle is a definite entity, continuous with the longitudinal muscle fibers of the ureters, and is superimposed upon the muscles of the bladder wall.

2. The opening of the vesical orifice during urination is not an inhibitory action, but is primarily the result of the contraction of the powerful trigonal muscle which passes in the form of an arc through the weaker arcuate muscles at the vesical orifice (the vesical "sphincter"), and pulls them open mechanically on contraction.

3. When the trigon is removed, micturition is difficult and incomplete; with removal of one half of the trigon, the remaining half functions and the bladder can be entirely emptied. The same is true when the trigon is split.

4. A split trigon is not functionally so perfect as one with Mercier's bar intact.

5. According to pharmacologic tests, nerve ganglions and true sympathetic fibers are present in the trigonal muscle, while the bladder wall has sympathetic and parasympathetic fibers.

6. The trigon is distorted in cases of renal tuberculosis, the shortened tuberculous ureter drawing the ureteral ridge outward on the bladder wall. It may cause invagination of the ureteral margin and elevation of the trigon on that side, the bladder wall being depressed about it.

7. If adhesions are present between the diaphragm and kidney, the shortened tuberculous ureter with respiration causes the trigonal ridge to play back and forth like a piston rod in the invaginated ureteral orifice.

8. There is a compensatory hypertrophy of the trigon in cases of obstruction at the vesical orifice, due to overexercise of the trigonal muscle in opening the vesical orifice. A corresponding atrophy follows the removal of the obstruction.

9. The force from the contraction of the trigonal muscle dissected partly free from the bladder wall, irrespective of the amount of hypertrophy, is not properly applied to help in the opening of the vesical orifice.

10. The contraction of a hypertrophied trigon, dissected free from the bladder wall, tends to form a damlike ledge dividing the bladder into two parts.

11. A diverticulum may form beneath the undermined trigon.

12. The obstruction due to a hypertrophied trigon can be removed: (1) intra-urethrally by means of a punch or a trigonotome; (2) perineally, by means of a scalpel or trigonotome; (3) suprapubically, by the use of scalpel and scissors.<sup>24</sup>

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24. In addition to the references already given, the following will be found of interest:

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## DIVERTICULA OF THE URINARY BLADDER

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CLEVELAND

Diverticulum of the urinary bladder, according to the literature on this subject, is a condition which has not received clinical recognition until comparatively recent years. Up to 1906, only five cases had been reported in the United States.<sup>1</sup> Since then, however, the number of cases has increased in proportion to the means available for the recognition of such a condition. Although the etiology of diverticula is still in dispute, during the last ten years much attention has been devoted to their treatment, and several operative procedures yielding satisfactory results have been devised.

### STRUCTURE AND LOCATION

The designation diverticula of the urinary bladder is applied to pouches which develop on the wall of the bladder. These may be large or small, single or multiple. They may involve the musculature of the bladder wall or merely the mucosa. Englisch makes a distinction between "true" and "false" diverticula, agreeing with Rathbun that "true diverticula comprise those cases in which there can be demonstrated in the wall of the diverticulum all the coats of the bladder;" whereas "false" diverticula comprise those "formed by mucous membrane only." Cabot holds a similar view.<sup>2</sup> The walls vary in thickness, the thickness as a rule increasing with the amount of inflammation of the diverticulum, although there may be a variation in different portions of the wall of a single diverticulum. Hinman notes that there is no epithelial lining of the lumen, and that the wall is not arranged in the definite layers which characterize the normal bladder wall. In all his cases he noted that the superficial layer next the lumen showed a chronic inflammatory reaction with engorgement of blood vessels and round-cell infiltration. "Muscle was invariably scattered in bands, interwoven with dense connective tissue. In not one case were definite muscle layers, as found in the bladder wall, demonstrable."<sup>3</sup> This appearance is indeed very characteristic. Diverticula have a smooth, glistening surface, resembling parchment, in contrast to the velvety appearance of normal mucosa. The size varies from that of an acorn to that of a

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1. Young, H. H.: Surg., Gynec. & Obst. **26**:125-132 (Feb.) 1918.

2. Englisch, J.: Arch. f. klin. Chir. **73**: 1904. Rathbun, N. P.: Surg., Gynec. & Obst. **29**:28-32 (July) 1919. Cabot, H.: Boston M. & S. J. **172**:300-302, 1915; *Ibid.* **172**:365-368, 1915.

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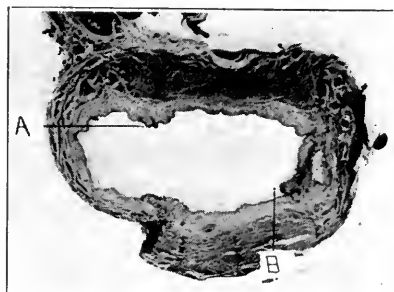


Fig. 1.—Cross-section of fetal bladder: *A*, outpushing of mucosa and submucosa along the lateral margin of the trigon; *B*, outpushing of the mucosa, submucosa and a portion of the muscular layer along the lateral margin of the trigon. (Reprinted by courtesy of Dr. E. M. Watson from *J. A. M. A.*, Nov. 27, 1920, p. 1473 )

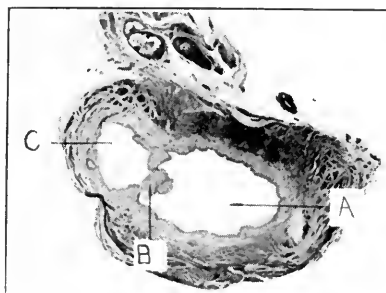


Fig. 2.—Cross-section of fetal bladder: *A*, bladder cavity; *B*, fold of mucosa and submucosa almost bridging the vesical cavity; *C*, cavity of a diverticulum in the process of formation. (Reprinted by courtesy of Dr. E. M. Watson from *J. A. M. A.*, Nov. 27, 1920, p. 1473.)

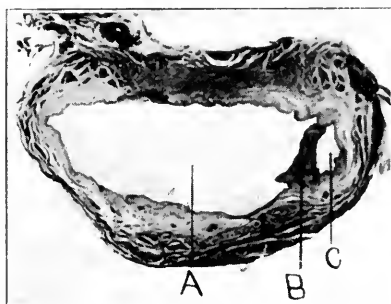


Fig. 3.—Cross-section of fetal bladder: *A*, bladder cavity; *B*, bridge of tissue composed of mucosa, submucosa, and some muscular fibers bridging the vesical cavity and attached to the opposite bladder wall (outline of the mucous covering still intact); *C*, cavity of diverticulum. (Reprinted by courtesy of Dr. E. M. Watson from *J. A. M. A.*, Nov. 27, 1920, p. 1473.)

baseball and may be even larger. Not infrequently the sac of the diverticulum is larger than the bladder itself, and its capacity greater.

Minute pockets, varying in size from those that are very small to others which are large enough to admit the tip of the index finger, nearly always surround diverticula. Hinman found such pockets in nine out of eleven cases of single diverticulum, and in all but one of his series of cases of multiple diverticula.

The most common location of diverticula is proximal to one of the ureters. It is interesting to note that in the cases cited in the literature, as well as in my own cases, more were proximal to the left than to the right ureter. This may be only a coincidence, however, for I do not believe that this observation has any particular significance. Diverticula are also frequently found on the posterior wall of the bladder; and Judd<sup>4</sup> reports their occurrence on the floor of the bladder or on one

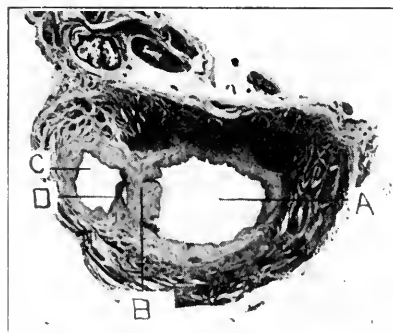


Fig. 4.—Cross-section of fetal bladder: *A*, bladder cavity; *B*, bridge of tissue traversing the bladder cavity; *C*, cavity of diverticulum; *D*, bridge of tissue dividing the cavity of the diverticulum and firmly attached to the opposite side. (Reprinted by courtesy of Dr. E. M. Watson from *J. A. M. A.*, Nov. 27, 1920, p. 1473.)

or the other of the lateral walls not far from the ureteral opening in thirty-nine out of forty-four cases, the greatest number—nineteen—being on the right wall near the base of the bladder. Howard<sup>5</sup> found several in the vertex, concluding therefore that each was a “vestigial urachus.” Large diverticula, because of the greater quantity of fluid they contain and the consequent increased pressure, force their way backward, and generally along the lines of least resistance until they become infected, and resultant inflammation develops. As a rule, the orifice of the diverticulum is quite small and entirely out of proportion to the size of the sac. The consequent difficulty in emptying it makes this type of diverticulum very resistant to palliative treatment.

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## ETIOLOGY

Although, during the last fifteen years, the etiology of diverticula has been the subject of careful study by many investigators, there is still much difference of opinion regarding it. Many believe that all diverticula are congenital; many others contend that they are always acquired; while still others believe that they may be either congenital or acquired.

According to Rathbun,<sup>6</sup> all "true diverticula are congenital." He considers that the so-called "acquired" diverticula are nothing more than "exaggerated trabeculations."

Cabot<sup>7</sup> leaves no doubt as to his opinion: "The word diverticula is confined to those pouches, *always of congenital origin*, occurring most frequently in certain localities of the bladder."

Englisch<sup>8</sup> makes the following classification: "The divided bladder and the true diverticula are congenital; the false diverticula are always acquired."

Howard<sup>5</sup> states that the theory that diverticula are acquired is based on the assumption that they are generally due to obstruction of the outlet of the bladder, and that for that reason they are practically limited to the male sex. His assertion that this assumption is not justified is based upon his observation in two of his own cases in women. However, my observation in my own cases of diverticula in women has been that there has usually been some interference with the complete emptying of the bladder as in one case of a large diverticulum in a woman<sup>9</sup> in which a very painful caruncle in the urethra prevented the patient from emptying the bladder as often and as frequently as is normal, thus producing a potential obstruction.

Thomas<sup>10</sup> supports the theory that diverticula are acquired, holding that "only in a few cases can a defective development account for the pathology," and further that "acquired factors seem necessary for the development of diverticula clinically."

Judd<sup>4</sup> says that "undoubtedly diverticula of the bladder may be congenital as instances have been reported in infants and small children, and it would certainly seem that in most of such cases there must have been some congenital defect in the bladder as a primary etiologic factor.

Whether the sac is composed of all the coats of the bladder or whether it is composed of the mucous membrane alone does not seem to draw a line between the etiology of the congenital and acquired types

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6. Rathbun, N. P.: Footnote 2, second reference.

7. Cabot, H.: Footnote 2, third reference.

8. Englisch, J.: Footnote 2, first reference.

9. Lower, W. E.: *Internat. Clin.* **4**:280, 1916.

10. Thomas, G. J.: *Surg., Gynec. & Obst.* **23**:378-384 (Oct.) 1916.

in these cases. There must be some congenital defect which will allow these sacs to develop, though their development may be aided and increased by an obstruction to the urinary outflow."



Fig. 5.—Drawings from roentgenograms of bladder, showing diverticulum: *A*, after injection with opaque solution; *B*, after removal of diverticulum.



Lerche<sup>11</sup> contends that both the muscular and the mucous diverticula may form before birth, and also that they may develop later in life; but that in either case they result from some obstacle to the outflow of urine.

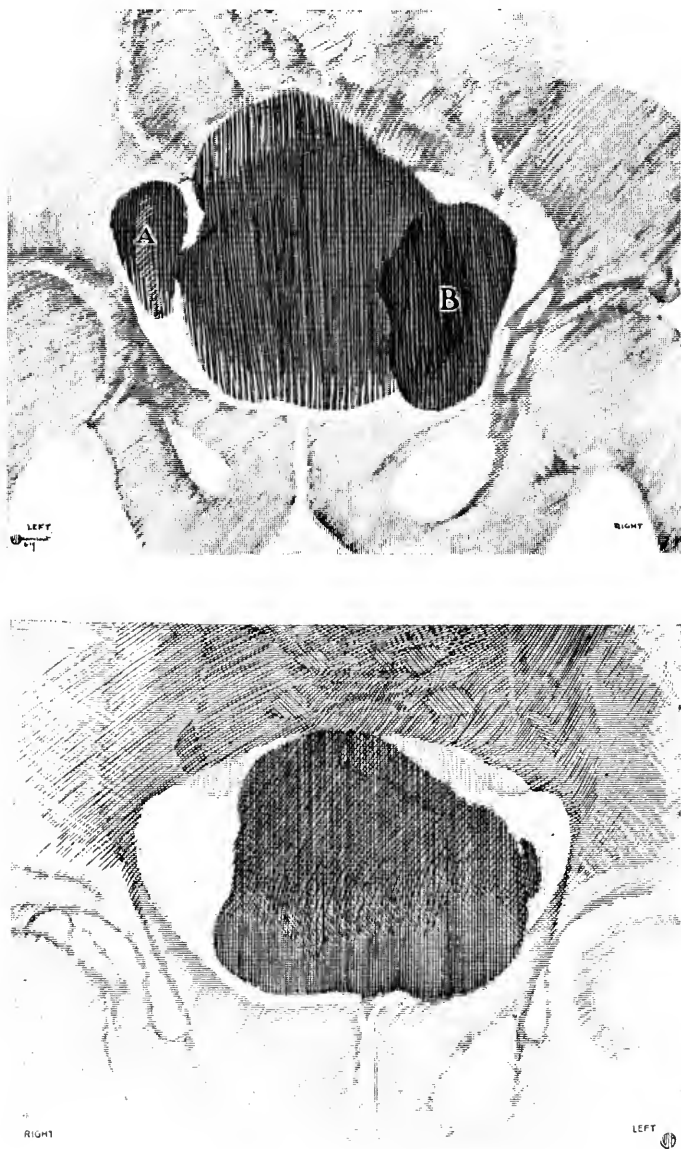


Fig. 6.—Drawings from roentgenograms of bladder: above, showing multiple diverticula; below, after removal of diverticula.

11. Lerche, W.: *Journal-Lancet* **32**:337-345, 1912.

Until recently it was my belief that all diverticula were acquired. Within the last year, however, the results of Watson's thoroughgoing

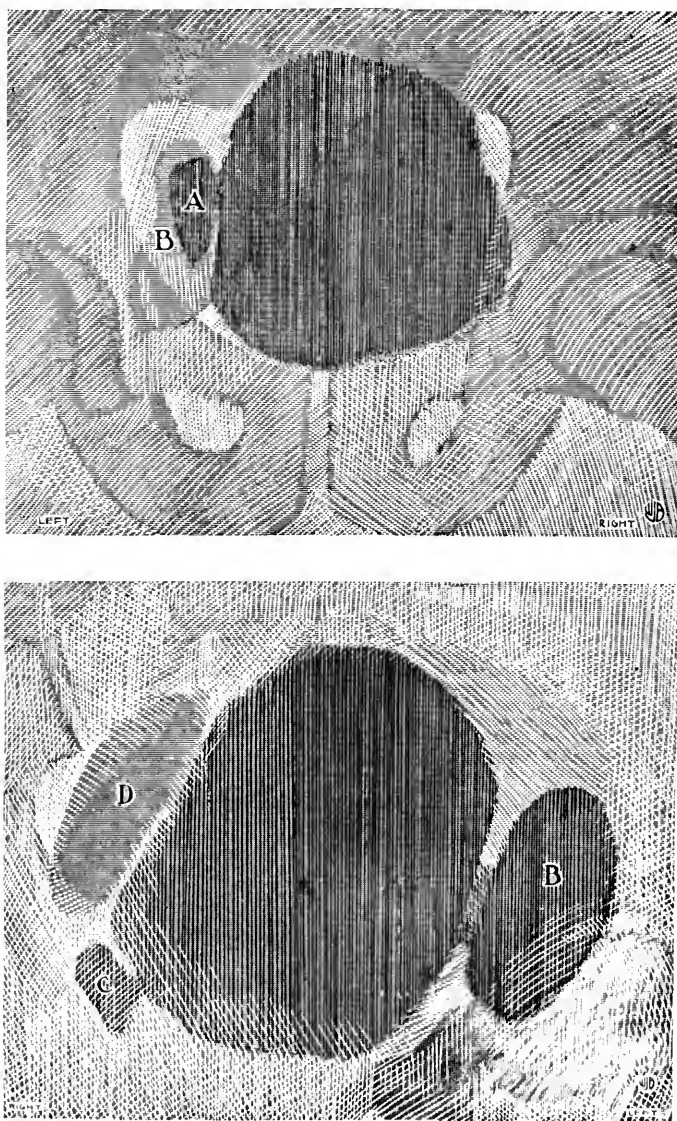


Fig. 7.—Drawings from roentgenograms of bladder; upper illustration showing multiple diverticula, only two of which are visible (*A* and *B*). Lower illustration taken at a different angle; diverticulum *A* is now concealed by *B*; but *C* and *D* are now revealed whereas in the upper illustration they were concealed by the bladder itself.

study<sup>12</sup> of fetuses with relation to diverticula have somewhat altered my opinion. In his study of the development of various portions of the lower genito-urinary tract, Watson observed "the vesical cavity in its progressive development from early fetal life until birth." In the course of these studies, the significance of certain pictures of the bladder cavity proved striking, and it appeared "that certain factors are present which may be of importance in determining the formation of diverticula" (Figs. 1, 2, and 3). The observation herewith quoted is so significant as to warrant repetition:

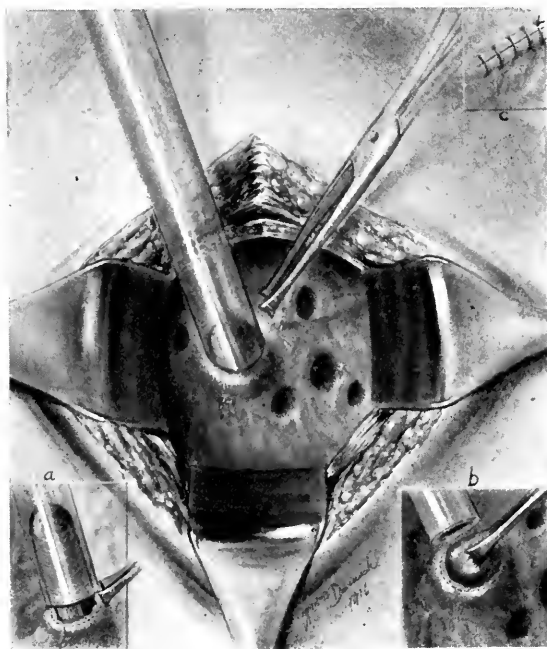


Fig. 8.—Six diverticula, lying posterior to the trigon were sucked into the bladder, stripped of their mucous linings, and closed: *a*, diverticulum being drawn up into tube; *b*, diverticulum released by tube and caught by clamp; *c*, diverticulum orifice closed. (Reprinted by courtesy of Dr. H. H. Young from *Surg., Gynec. and Obst.*, February, 1918, p. 125.)

The site of transition from the trigon, with its thick musculature and its covering of many layers of epithelial cells, to the lateral bladder wall with only two or three layers of epithelial cells is prone to produce a ridgelike demarcation which readily lends itself to the formation of an excess of epithelial tissue. The apposition then of two surfaces of the bladder wall denuded of epithelium, at a time when true formative growth is active, results first in adhesions and later in a true attachment of a bridge of tissue across a portion

12. Watson, E. M.: The Developmental Basis for Certain Vesical Diverticula, *J. A. M. A.* **75**:1473-1474 (Nov. 27) 1920.

of the vesical cavity (Fig. 4). The growing submucosa and muscularis become continuous from the finger-like evaginations with that of the opposite side, and in the older specimens this ridge of tissue is shown to contain all three layers of the muscular coats of the bladder. The mucosa in its growth then becomes continuous from the finger-like evaginations with that of the opposite bladder wall, and there is formed a true pocket within the bladder, the walls of which have all the essential elements of the true bladder wall, namely, the three muscular coats, the submucosa and the mucosa.

In the light of Watson's observations, it seems probable that there is a congenital predisposition to diverticula, but that "their clinical recognition during adult life is hastened and their dimensions greatly increased by any of the factors that would bring about increased vesical



Fig. 9.—The left ureteral orifice lay within the diverticulum. After invagination of the diverticulum, a horse-shoe incision was made around the sac so as to preserve the interureteral ridge. The lining membrane (mucosa and submucosa) is being peeled up, and the underlying tissue (including ureter) pushed back. Ureter was palpable, and indistinctly visible, although it was not dissected free: *U*, ureter. (Reprinted by courtesy of Dr. H. H. Young from *Surg., Gynec. and Obst.*, February, 1918, p. 125.)

distention or increased activity of the bladder musculature." The fact that diverticula usually occur in patients past middle age and almost invariably in the male, with the concomitant presence of obstruction, seems to confirm such a theory. With the congenital weakness of the bladder wall aggravated by pressure, due to obstruction of the urinary outlet, it is evident that diverticula may readily form; as also in cases in which an overdistended condition of the bladder is due to failure to empty it at regular intervals. Two rather striking examples

of diverticula, apparently due to the latter condition, have come under my observation. Both patients were mail carriers, and each stated that he attributed his difficulty to the fact that on the mail route it was not always convenient to empty the bladder and that, therefore, he had held his urine much longer than under ordinary conditions.

An analogous pathologic condition, due to a congenital defect, is diverticulum of the esophagus, which has been very well described and illustrated by Bevan<sup>13</sup> in a recent number of the *Journal of the American Medical Association*. He says in part:

Diverticula of the esophagus, just as inguinal hernias, always occur at exactly the same point. . . . Pulsion diverticula present themselves at the junction of the esophagus and the pharynx in the median line posteriorly. At this point there is a triangular area where the oblique muscles of the pharynx and the transverse circular muscles of the esophagus meet, leaving a small area not covered with musculature but simply by a subcutaneous layer. In cases in which a diverticulum develops it is probable that there is more than the usual normal weakness at this point, probably a congenital absence of muscle fiber over a large area, permitting a pushing out of the mucosa and submucosa in the process of deglutition, so that with this impulse applied to this weak area during swallowing, a pouch of mucous membrane and submucosa is pushed out through this small triangular defect. The neck of the pouch always remains comparatively small. The pouch itself may reach a size sufficient to hold 8 or 12 ounces, or even more.

The latter characteristics are strikingly like those of bladder diverticula. Bevan goes on to say that whereas the small diverticula are of little moment in their effect on the health and comfort of the patient, the larger diverticula may become a "serious menace" as food will lodge in them, decompose, and cause infection. This again is analogous to the menace presented by the stagnant urine in the diverticula of the bladder.

#### DIAGNOSIS

One reason for the paucity of reports on diverticulum until comparatively recent years is doubtless the fact that even if the existence of such a condition was suspected, the profession did not have at hand the means whereby to diagnose it properly. The advent of the cystoscope and the more recent application of the roentgen ray are principally responsible, I believe, for the change in the situation (Figs. 5 and 6).

According to Hinman, the cystoscope and roentgen ray are essential in making an absolute diagnosis of the presence of diverticula. He believes that the cystoscopic study should be systematic, and that the method of choice is that advocated by H. H. Young. Because of the

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13. Bevan, A. D.: Diverticula of the Esophagus, *J. A. M. A.* **76**:285-288 (Jan. 29) 1921.

possibility of insufficient or faulty diagnosis after careful cystoscopic search, he believes that the importance of the cystogram, and of contrast cystograms in particular, cannot be overemphasized:

Neither cystoscopy nor cystography alone is sufficient. The cystoscope is unreliable for accurate determination of the size and position, and the simple cystogram may fail to show even a large diverticulum. But when cystoscopy, plain cystography, and contrast cystography are properly used in conjunction, they establish a definite diagnosis. The coiling of the roentgen-ray catheter into the diverticulum through its orifice is also occasionally useful.

Howard considers cystoscopy essential in making out the orifice of the diverticulum. Further than this, however, "the high degree of cystitis which is usually present makes identification of other landmarks than the diverticulum impossible. Much information can be derived from a shadowgraph (the bladder having been distended with an opaque fluid such as one of thorium nitrate, 10 per cent.) provided the diverticulum lies in such a position that its outline may not be obscured by that of the bladder." In this connection, it should be remarked that roentgenograms should be made at different angles in order to reveal diverticula which might otherwise be hidden by the bladder, itself; or in the case of multiple diverticula, by another diverticulum (Figs. 7 and 14).

Rathbun<sup>14</sup> advises preliminary diagnosis by routine cystoscopy and by passing the ureteral catheter into the diverticulum. "More accurate estimation of size, shape, and location of the wall of the diverticulum may be obtained by employment of cystography." For this he uses a 25 per cent. solution of sodium bromid. He states further that cystograms should be made in two diameters and stereoscopically, and that because of infection in the bladder, cystoscopy is not always simple, and it is often necessary to employ prolonged irrigation before a satisfactory view can be obtained. In very difficult cases he believes that other symptoms such as the character of the urine, cystography, and rectal examination must be relied on. Foul smelling, cloudy urine which it is difficult to clear may be an indication of the existence of diverticulum, though, of course, this symptom of itself is not a sufficient basis for diagnosis. As a last resort, exploratory cystotomy may be indicated. Occasionally a hematuria is present as has occurred in several cases in my own series.

Judd<sup>4</sup> expresses the following opinion: "Accurate determination of the condition rests with the cystoscopic examination, and the employment of the leaded catheter, and roentgen rays, or by the making of a cystogram which is of great value in any doubtful case." Diagnosis is often difficult because of obstruction and infection; hence it is

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14. Rathbun, N. P.: Footnote 2, second reference.

wise to "emphasize the necessity of a careful exploration of the bladder at the time of performing the prostatectomy in cases showing marked cystitis and infection at the time of the examination. A diverticulum should be suspected in the patient who has undergone a prostatectomy and still has a considerable amount of residual urine, particularly if there is much evidence of infection which does not respond to the ordinary treatment. . . . Bladder trabeculation, three on a scale of four, was noted in thirty-eight out of the forty-four patients."



Fig. 10.—Conversion of diverticulum into a tumor by gauze packing.

Fischer<sup>15</sup> emphasizes the necessity for early and accurate diagnosis if untoward results for the patient would be avoided.

Further opinions might be quoted, but these are sufficient to indicate the general uniformity of opinion. It will be noted that there is a consensus of opinion that with the aid of the cystoscope, the cystogram, and the roentgen ray, plus the case history, a fairly accurate diagnosis may be obtained. However, no matter how careful and clear the preoperative diagnosis, one must be prepared for surprises and

15. Fischer, H.: *Surg., Gynec. & Obst.* **10**:156-168, 1910.

difficulties at operation; for a diverticulum which shows very clearly in the roentgenogram may be difficult to locate amidst the wrinkles, "hills and valleys" of the interior bladder wall.

It should be noted further that when prostatectomy has been indicated, the possible presence of a diverticulum should be searched for routinely at the time of the operation, lest a second operation become necessary later.

#### SYMPTOMATOLOGY

Diverticula present no definite symptomatology. However, when there is difficulty in micturition, combined with frequency, and evidence of infection, this condition may be suspected. If two or more

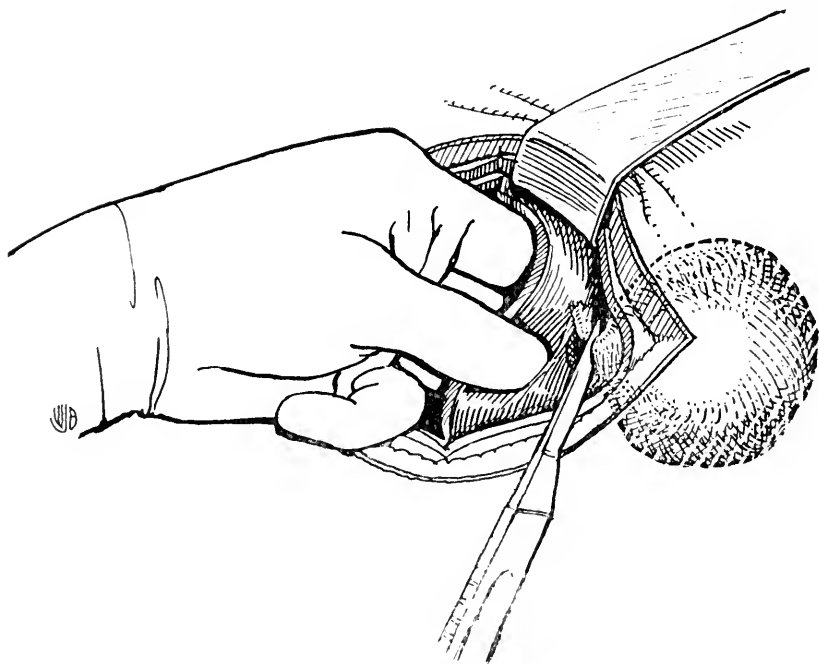


Fig. 11.—Severing the attachments of the diverticulum outside the bladder, after the conversion of the diverticulum into a pseudotumor.

successive micturitions are required to empty the bladder, the presence of a diverticulum may be indicated, particularly if the first urine voided is comparatively clear, and is followed by thick, foul smelling urine. Retention may quite possibly point to the presence of diverticula. Occasionally hematuria is present. In the absence of stone in the kidney or bladder, the presence of large amounts of pus in the urine, which does not clear readily on irrigation, enhances the probability of a diverticulum. None of these symptoms, however, is sufficiently accurate for definite diagnosis without the use of the cystoscope and roentgen ray.



## TREATMENT

The following surgical procedures in the treatment of diverticula of the bladder have been reported: (1) suture of the orifice of the diverticulum without excision of the sac (Pousson<sup>16</sup>); (2) enlargement of orifice (Pousson and Chute<sup>17</sup>); (3) radical excision of diverticulum in toto (Young, Hinman, Howard, Lower, Squier,<sup>18</sup> and others).

Surgeons who have had the widest experience in the treatment of diverticula seem agreed that complete excision is the only procedure which leads to permanently satisfactory results. Moreover, there is a

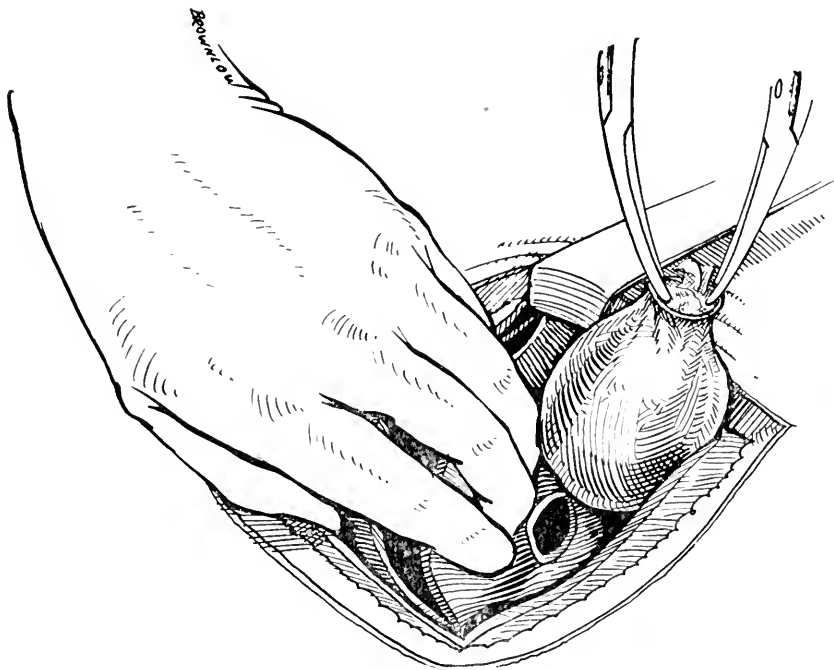


Fig. 12.—Removal of diverticulum.

unanimity of opinion that, since obstruction in some form is nearly always an important factor in the development of a diverticulum of sufficient size to be brought to clinical notice, the cause of such obstruction should be removed with the diverticulum if recurrence of the malady is to be avoided.

Of the two possible methods of excision, extravesical or intravesical, the latter seems to be the most favored, especially by Rathbun, English and Young. In 1909, Young advocated the intravesical excision of

16. Pousson, quoted by von Eberts: *Ann. Surg.* **1**:883-900, 1909.

17. Rathbun: Footnote 2, second reference.

18. Squier, J. B.: *New York M. J.* **99**:1026-1028, 1914.

diverticula, and in recent years he has become more and more impressed with the importance of this method whenever possible, particularly for the excision of the intraperitoneal, retrovesical, subtrigonal types. Young's intravesical suction enucleation method is now well known. He summarizes it as follows: "Invagination of diverticulum by suction and traction; intravesical enucleation of the sac of the mucosa, thus entirely avoiding sharp dissection and pushing the ureter (if present) back into the bladder; intravesical closure; extravesical drainage of region of diverticulum; plastic operation, punch or prostatectomy, to cure obstructive cause of diverticulum" (Figs. 8 and 9). It has been my experience that this method is excellent when dealing with small diverticula which are in such a position as to be readily picked up with the forceps and drawn into the bladder.

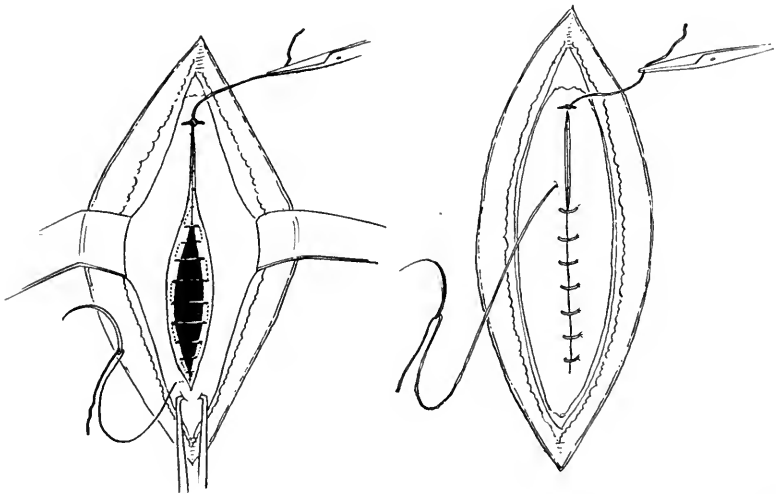


Fig. 13.—Closure of bladder after removal of diverticulum: *A*, apposition suture; *B*, interlocking suture.

Rathbun employs both intravesical and extravesical manipulation, but invaginates the sac and completes the operation from within the bladder.

He also advises a two-stage operation in difficult cases, giving preliminary prolonged drainage and forcibly stretching the orifice of the diverticulum at the first seance and delaying excision of the diverticulum until the second operation. This has not seemed to me to be a logical procedure.

Whether the incision shall be intraperitoneal, extraperitoneal or paraperitoneal must be decided by the factors in the individual case. Kreissl<sup>19</sup> prefers the extraperitoneal route whenever possible. In order

19. Kreissl, F.: Mississippi Valley M. J. **24**:45-54, 1917.

to follow this method for the removal of diverticula on the posterior wall, he uses a transverse rather than a vertical incision. The disadvantages of the transverse incision are that in case a second operation has to be performed, there is greater danger of postoperative hernia than with a vertical incision.

In our clinic the following operative technic is employed. A median suprapubic incision is used, through which the bladder is brought for-

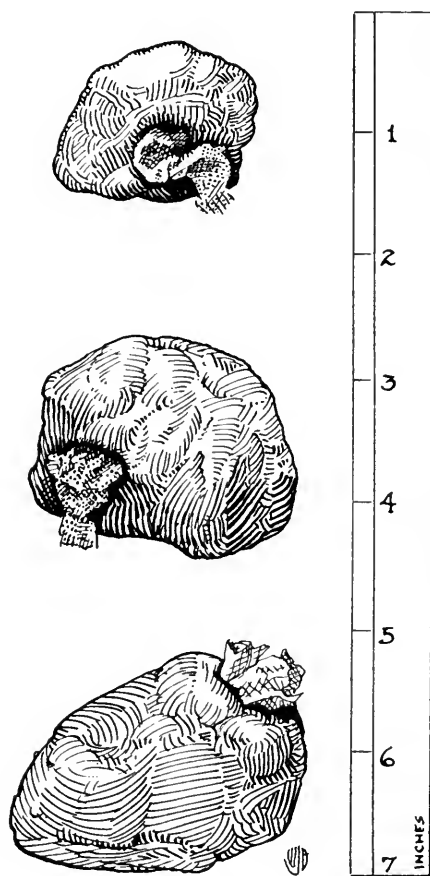


Fig. 14.—Diverticula removed in case shown in Figure 7.

ward and opened. With the roentgenograms as a guide, the diverticula are then located, their size and location determining the method of excision. Whether the diverticula, which gave rise to the symptoms leading to operative treatment, be single or multiple, there are sure to be very small pouches—miniature diverticula—in the vicinity. It is not always an easy matter to decide quickly at operation how to deal with these secondary pouches. It has generally been found safe, however,

to leave the very small diverticula, if the cause of obstruction is removed at the same time as the diverticula which are of sufficient size to leave no doubt as to the advisability of excision. Unless some other cause of obstruction should arise later, these tiny pockets will not develop further, and will, therefore, cause the patient no discomfort.

For small diverticula which are so situated that they can be readily picked up with the forceps and drawn into the bladder, I have found the intravesical route most satisfactory. With the large diverticula, however, especially those located on the posterior wall, I have found it most satisfactory to pack them with gauze and to remove them extravesically, treating the diverticulum as if it were a tumor. This method has been previously described in *International Clinics*. The collapsed diverticulum is first converted into a solid or semisolid tumor by packing it tightly as shown in Figure 10. It then becomes a comparatively simple matter to dissect down outside the bladder, severing the attachments of the diverticulum and closing the opening into the bladder (Figs. 11 and 12). It is important that the closure of the bladder at the point of removal of the diverticulum be made with good muscular apposition, the walls being inverted, if possible, so as to leave a slight ridge on the inner surface of the bladder rather than a depression at the point from which the attachment of the diverticulum was removed, as such a depression might serve as the focus for a recurrence of the diverticulum. The prevesical space should always be carefully drained. The closure of the bladder is made with catgut sutures, first an apposition suture, bringing the two cut surfaces in approximation; and then an interlocking suture, passing entirely through the muscular wall (Fig. 13). An inlying catheter is placed in the urethra and allowed to remain for several days.

Should hemorrhage occur after the cause of obstruction has been removed, as after prostatectomy, for example, we have found it advisable to keep the patient on the operating table and to apply gauze soaked in cephalin to the bleeding surface until the hemorrhage is arrested. A delay of a few minutes with the patient under nitrous-oxid-oxygen is usually not a serious matter, whereas returning the patient to his room with a hemorrhage may prove to be.

For the removal of diverticula in which the ureter is involved, various methods have been employed. Whatever method is used, it is quite important to assure the maintenance of the physiologic function of the ureter by transplanting it so that it runs for a distance just beneath the mucous membrane, thus reproducing its natural course. Otherwise the ureter will soon dilate with resultant increased danger of kidney infection.

## PROGNOSIS

The prognosis as a rule is favorable. The immediate mortality rate of the well directed operations should not be very great; for no serious operation should be undertaken until the patient has been brought to the best possible condition. This means that in addition to general hygienic measures the kidney function should be assured and the infection cleared up as far as possible before the operation. The chances of recurrence depend on the manner in which the opening from which the diverticulum has been removed has been closed. As previously stated, if the musculature is not well adjusted, or if any defect is left, it will be the starting point of a recurrence; and if the obstruction of the urinary outlet is not removed, other diverticula will certainly develop. In certain cases in which multiple diverticula and an obstruction have been removed, the whole procedure seems to have interfered with the power of the bladder to empty itself completely, so that in certain cases there has been some residual urine. Whether this is due to some interference with the innervation of the bladder wall has not been definitely determined. As many of these cases follow a prolonged infection, as a result of which an ascending infection has developed, pus is often found in one or both kidneys. Unless the drainage is very complete, this process will in all probability continue, thus making the outlook for a complete recovery less promising.

The relief which results from radical operation is so great as compared with that secured by palliative measures that there can be no doubt that radical operation is to be considered the method of choice.

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## TUMORS OF THE BONY CHEST WALL \*

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ROCHESTER, MINN.

The first recorded thoracotomy for tumor was reported by Osias Aimar<sup>1</sup> in 1778. Von Speicher,<sup>2</sup> in 1881, reported twenty-eight cases collected from the literature, but only a few of these had been treated surgically. Parham,<sup>3</sup> in 1898, reported two cases of his own in which successful operations had been performed, and 101 cases from the literature. This series included the smaller series previously reported by von Speicher,<sup>2</sup> Quénu and Longuet,<sup>4</sup> and others. In 1913, Lund<sup>5</sup> added twenty-seven cases to the list, including one of his own. I have found thirty-five additional cases in the literature, and twenty-three in the records of the Mayo Clinic since 1910, making a total of 188. The case reports of Gross,<sup>6</sup> Stukkei,<sup>7</sup> Hervy,<sup>8</sup> Degorce,<sup>9</sup> Palleroni,<sup>10</sup> and Zschucke<sup>11</sup> were not available. For statistical purposes, twenty-five cases from the Mayo Clinic in which operations were not performed are included, making 213 in all.

This classification is that of the main histologic divisions. The classification by subgroups is given in Table 2.

Two of the cases of recurrent carcinoma were in the chest wall, following amputation of the breast in the female; two were in the male breast. One was a hypernephroma secondary to a tumor of the kidney

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\* From the Section on Surgery, Mayo Clinic.

1. Aimar, O.: Quoted by Parham, Footnote 3.

2. Von Speicher, S.: Quoted by Campe, G.: *Ueber Tumoren der knochernen Thoraxwand*, Göttingen, 1894.

3. Parham, F. W.: *Thoracic Resection for Tumors Growing from the Bony Wall of the Chest*, New Orleans, 1899.

4. Quénu, E. and Longuet, L.: *Des tumeurs du squelette thoracique*, *Rev. de chir.* **18**:365-402, 1898.

5. Lund, F. B.: *Sarcoma of the Chest Wall*, *Ann. Surg.* **58**:206-217, 1913.

6. Gross, G.: *Sarcomes étendues de la région sterno-claviculaire; extirpation; autoplastique par glissement et décollement*, *Rev. méd. de l'est* **45**:497-500, 1913.

7. Stukkei, L. G.: *Case of Chondrosarcoma of the Manubrium Sterni*, *Russk. Vrach.* **14**:977, 1915.

8. Hervy, M. J.: *La chondrectomie (opération de Freund) est-elle une intervention bénigne?* Bordeaux, Cadoret, 1915.

9. Degorce, A.: *Sarcome de la paroi antero-latérale du thorax à prolongement intrathoracique*, *Bull. Soc. méd.-chir. de l'Indo-Chine, Hanoi and Haïfong*, **5**:160, 1914.

10. Palleroni, G.: *Sopra un caso di encondrosarcoma della parete toracica*, *Clin. med.* **9**:393-396, 1903.

11. Zschucke, J.: *Ueber einen Fall von Myxochondrosarkom der Rippe bei einem wölfjährigen Mädchen*, München, Müller and Steinicke, 1912.

on the same side; one was secondary to a cancer of the thyroid; one was a primary epithelioma of the chest wall with involvement of the manubrium, and one was an adenocarcinoma.

It is noteworthy that while 62.4 per cent. of the cases were sarcoma, more than 8 per cent. were combinations of chondroma and sarcoma, and probably originated as chondroma.

TABLE 1.—TYPE OF TUMOR

Pathologic Classification	Hedblom	Parham	Lund	Total
Chondroma .....	11	25	4	40
Sarcoma .....	53	65	13	131
Carcinoma .....	12	5	7	24
Fibroma .....	2	3	..	5
Exostosis .....	3	..	..	3
Gumma .....	..	1	..	1
Uncertain .....	2	4	3	9
Total .....	83	103	27	213

TABLE 2.—RELATIVE INCIDENCE IN FORTY-EIGHT CASES: MAYO CLINIC

Pathologic Classification	Cases
Chondroma .....	2
Osteochondroma .....	1
Sarcoma (unspecified) .....	13
Spindle-cell sarcoma .....	3
Round-cell sarcoma .....	7
Osteosarcoma .....	3
Chondrosarcoma .....	2
Myxochondrosarcoma .....	1
Osteochondrosarcoma .....	1
Fibroma .....	2
Carcinoma .....	4
Adenocarcinoma .....	1
Epithelioma .....	1
Nonmelanotic melano-epithelioma .....	1
Hypernephroma .....	1
Periostitis .....	3
Questionable .....	2
Total .....	48

In 167 (78.7 per cent.) of the 213 cases, the tumors were of the ribs, and forty-six (21.3 per cent.) were of the sternum. Sixty-two and eight-tenths per cent. of the tumors of the ribs were sarcoma and 19 per cent. were chondroma. Fifty-four and three-tenths per cent. of the tumors of the sternum were sarcoma and 13 per cent. were chondroma.

In 61 per cent. of 128 cases in which location was mentioned, the right side was involved. In twenty-one of fifty-nine cases, the upper

thorax was involved, the lower was involved in thirty-eight. The anterior aspect of the thorax was affected in thirty-two cases, the lateral in nineteen, and the posterior in eight. The first rib was involved in one case only. A single rib was affected in twenty-two cases, two ribs in twenty-two cases, three in eighteen cases, four in thirteen cases, five in four cases, and seven in one case. The manubrium appeared chiefly affected in twenty-six of the forty-one sternal cases, the gladiolus in eleven, and the xiphoid in two.

In 129 cases, the size of the tumor was variously described: as that of a hazelnut in ten; from that of an egg to that of an orange in

TABLE 3.—AGE AND SEX

Age	Hedblom	Parham	Lund	Total
Under 10 .....	2	1	..	3
11 to 20 .....	8	13	4	25
21 to 30 .....	15	18	3	36
31 to 40 .....	16	21	2	39
41 to 50 .....	11	14	3	28
51 to 60 .....	13	19	1	33
61 to 70 .....	13	1	1	15
71 to 80 .....	2	..	..	2
Not stated .....	3	16	13	32
Total .....	83	103	27	213
Sex	Hedblom	Parham	Lund	Total
Males .....	48	61	7	116 (62.3%)
Females .....	35	32	3	70
Not stated .....	..	10	17	27
Total .....	83	103	27	213

TABLE 4.—DURATION OF TUMOR

	Chondroma	Sarcoma
Less than one year .....	6 (23%)	38 (34.5%)
One to six years .....	12 (46%)	60 (54.5%)
More than six years .....	8 (31%)	12 (10.9%)
Total .....	26	110

seventy-two, and from that of a grapefruit to that of an adult head in forty-seven. In the Mayo Clinic and collected series three were from 1 cm. to 2 cm. in diameter, thirty-eight from 5 cm. to 12 cm., and seventeen from 15 cm. to 30 cm.

The tumor had been present in about 39 per cent. of the 126 cases less than one year, and in about 74 per cent. less than four years.

#### ETIOLOGY

There usually is no history of trauma in tumors of the chest wall, but the absence of such a history is not conclusive proof that the origin



was not traumatic. Minor injuries, as a rule, are quickly forgotten. Furthermore, chest tumors are more common in males, who are more subject to trauma, and the area involved is usually the more exposed anterior or lateral portion of the chest. Thus, of the cases in this series in which sex and site were specified, the tumor occurred in males in more than 62 per cent., on the right side in 60 per cent., and on the exposed upper anterior part of the chest in more than 85 per cent.

The apparent influence of trauma on the development of a tumor, which, however, may remain small and apparently dormant for some time, is well illustrated by Cases 3, 12, 13 and 14. The apparent accelerating effect of secondary trauma and of operation when complete extirpation was not attained is a striking finding in Cases 2, 7, and 14.

Amburger<sup>12</sup> and Tietze<sup>13</sup> report cases in which the growth followed pregnancy, and in Tietze's case the tumor grew in three periods following three successive pregnancies during nine years.

#### SYMPTOMATOLOGY

Aside from the presence of a tumor, pain is the most characteristic symptom. Some degree of soreness or pain was present in 50 per cent. of my personal and collected cases. Loss of weight was noted in fifteen (31.2 per cent.). Dyspnea was present in only four, and effusion in two.

In many cases, pain is present before there is any discernible growth, as in my Case 10 and the cases reported by Hesse,<sup>14</sup> Sourdille,<sup>15</sup> Busse,<sup>16</sup> and others. This may be accounted for by the fact that in some instances the growth begins on the pleural aspect and early infiltrates the pleura and involves the intercostal nerves. Busse reports a case of myxochondrosarcoma originating in the pleura and encroaching exclusively on the pleural cavity, causing great pain and dyspnea, and finally death. A painless tumor may be present for years, and then suddenly become very painful (Case 9). The onset of pain may be incident to sarcomatous degeneration, but a chondroma may also be painful. The unreliability of this symptom as a criterion in the differential diagnosis of malignancy is shown by the fact that while pain

12. Amburger, N.: Zur operativen Behandlung der Brustwand- und Mediastinalgeschwülste, *Beitr. z. klin. Chir.* **30**:770-804, 1901.

13. Tietze, A.: Beiträge zur Resection der Thoraxwandungen bei Geschwülsten, *Deutsch. Ztschr. f. Chir.* **32**:424-437, 1891.

14. Hesse, O.: Beitrag zur Differential-diagnose der Thoraxtumoren, *Fortschr. a. d. Geb. d. Roentgenstrahlen* **18**:246-256, 1911-1912.

15. Sourdille, G.: Ostéosarcome des côtes chez un enfant de 11 ans, *Gaz. méd. de Nantes* **27**:31-33, 1909.

16. Busse, O.: Ueber ein Chondro-Myxo-Sarcoma pleurae dextrae, *Virchows Arch. f. path. Anat. u. Physiol.* **189**:1-11, 1907.

was present in thirty-four of forty-nine cases of sarcoma (almost 70 per cent.) in my own and Parham's series, it was present in five of twelve cases of chondroma.

The physical examination gives little evidence of the nature of the tumor. A smooth surface is characteristic of chondroma, a nodular irregular surface, of sarcoma; but inasmuch as sarcoma frequently develops in chondroma, this finding is always of uncertain value. Enlarged regional glands are present only occasionally.

#### DIAGNOSIS

In typical well advanced cases, the diagnosis of neoplasm is certain; but in early cases, a definite diagnosis may be impossible. Cold abscess, exostosis, gumma, aneurysm, and dermoid cyst must be differentiated. Derynzhinski<sup>17</sup> and Walther<sup>18</sup> report resection of the chest wall for deep seated lipoma simulating sarcoma. Cases that at operation prove to be inflammatory may have a history typical of neoplasm (Case 1). Pulsating sarcoma may simulate aneurysm. Exostosis may be impossible to differentiate in the early stage without an exploratory operation (Cases 4, 5 and 6). In case of a deep seated tumor, particularly beneath the heavy muscles posteriorly, there may be no external tumor, as in the cases reported by Lejars,<sup>19</sup> Baldwin<sup>20</sup> and Matry,<sup>21</sup> and as has been noted, there may be only pain, and possibly loss of weight. Such cases are often diagnosed intercostal neuralgia. A case of a tumor developing under the female breast is reported by Amburger. Dermoid cysts of the sternum are reported by Bird,<sup>22</sup> Calvalcanti,<sup>23</sup> and others. The differentiation of types of neoplasm is also uncertain, particularly on account of the tendency to malignant degeneration of the benign forms. It may also be impossible to distinguish between a primary and a metastatic growth (Case 10).

#### TREATMENT

Early radical extirpation has been generally accepted as the treatment of choice. The accepted indications and contraindications to

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17. Derynzhinski, S. F.: Excision of a Considerable Portion of the Thorax Together with the Pleura for Primary, Very Rare Tumor of the Rib, Ending in Recovery, *Khirurgia, Mosk* **15**:417-423, 1904.

18. Walther, C.: Lipome périostique congénital de la paroi costale, *Bull. et mém. Soc. de Chir. de Par.* **40**:367-370, 1914.

19. Lejars, F.: Les tumeurs, de siège anormal, du squelette thoracique, *Semaine méd.* **34**:16, 1914.

20. Baldwin, J. F.: Sarcoma of the Chest Wall, *Ann. Surg.* **58**:853-855, 1913.

21. Matry: Quoted by Lejars, Footnote 19.

22. Bird, A. C.: A Case of Dermoid Cyst of the Sternum, *Lancet* **2**:1215, 1904.

23. Cavalcanti, M.: Observation sur un cas de kyste dermoïde préexternal, *Tr. Internat. Cong. Med.* 1913, London, 1914, Sect. vii, Surg., Pt. 2, 219.

operation, however, have been various, depending chiefly on considerations of operative pneumothorax, proneness to recurrence in case of malignant tumors, and supposed innocuous nature of tumors considered benign.

A radical operation was performed in ten of the forty-eight cases in the Mayo Clinic; a more or less palliative excision with cautery was performed in thirteen. One patient refused operation. The remaining twenty-four were considered inoperable. In one case of the first group (Case 10), the excised tumor was found to be an adenocarcinoma. No evidence was elicited before or after operation of a primary tumor elsewhere. Necropsy six months after operation, however, revealed a primary growth in the suprarenals. This is an example of an absolute but unrecognizable contraindication to operation. Of the thirteen cases in which a less extensive operation was performed, there was roentgen-ray evidence of metastasis in four; three were cases of carcinoma with extensive infiltration. One patient was four months pregnant. In the remaining five cases, the tumor was excised and cautery applied; but the operation was less extensive than in the first group, and in no case was the pleural cavity opened.

In the group of twenty-five patients not operated on, tissue was removed for biopsy in fourteen. One patient refused operation. There was roentgen-ray evidence of metastasis in eleven. Two patients had carcinoma. Four tumors were diagnosed inflammatory by microscopic examination; three were periostitis. In six cases, the condition was considered too extensive for excision, and one patient was in too poor condition to withstand operation.

Many of these patients, operated on and not operated on, had radium and roentgen-ray treatment; most of them after operation only, but some before operation as well as after, but without definite permanent cure, so far as is known. Marsh,<sup>24</sup> Turner<sup>25</sup> and others report cases apparently cured by radiotherapy.

The contraindications to radical operation in this group were metastasis, very extensive involvement in a case of sarcoma and chondroma, deeply infiltrating carcinoma, periostitis, and advanced cachexia. The diagnosis of metastasis may be erroneous. In one instance in this series, the roentgen ray revealed apparent involvement of the upper lobe of the lung. The patient, however, is alive after more than three years. The tumor of the chest wall has grown to enormous proportions; but nothing has developed to substantiate the early diagnosis of metastasis.

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24. Marsh, J. P.: A Case of Supposed Sarcoma of the Chest Wall Symptomatically Cured by Means of the X-Ray. *Am. J. M. Sc.* **127**:1055-1056, 1904.

25. Turner, D.: A Case of Myeloma of the Sternum Treated by Radium, *Brit. M. J.* **2**:218, 1915.

When there is uncertainty as to metastasis, the finding of Bence-Jones protein in the urine may be confirmatory. In two instances in this series in which the urine contained Bence-Jones protein, there was multiple metastasis in the bones. One was a case of chondroma of long standing (Lemon,<sup>26</sup>) the other a case of round-cell sarcoma in which the roentgen ray revealed multiple unsuspected metastases in the skull and pelvic bones.

The cases found at operation to be inflammatory are examples of a relative indication for operation, as an early diagnosis could not be made by other means.

The operability of carcinoma involving the chest wall is probably at best doubtful. Schede<sup>27</sup> exhibited a case symptom-free one year after operation for recurrence following breast amputation. Sauerbruch<sup>28</sup> uses the opposite breast dissected free from the pectoral fascia and with a wide pedicle to cover over the defect after breast amputation with resection of the chest wall. Fink<sup>29</sup> reported a case free from recurrence three and three-fourths years after resection. A few other cases with apparent cure have been reported.

Extensive infiltration with involvement of adjacent structures is not considered a contraindication by some surgeons. In my collected series, portions of the diaphragm were removed in six cases. One patient died after operation, the other five had recurrences. The transverse process of one vertebra was removed in one, but the tumor recurred. In one instance reported by Amburger,<sup>12</sup> the clavicle, the first and second ribs, and the sternum were resected, and both pleural cavities were opened. The patient died the third day after the operation, cause not stated. Mayer<sup>30</sup> opened both pleural cavities in resecting the sternum; the patient died the ninth day of empyema. Ligation of the jugular veins and the suture of a tear in the innominate vein is reported by Lanphear<sup>31</sup> in a case of resection of the sternum.

In Lund's<sup>5</sup> series the diaphragm was injured in six cases, with postoperative recovery. In one case the pericardium was opened with operative recovery. In one case (Lockwood<sup>32</sup>) the diaphragm, pericardium, and part of the lung were resected, but recurrence followed.

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26. Lemon, W. S.: Chondroma of the Thorax, *Journal-Lancet* **39**:59-60 (Feb. 1) 1919.

27. Schede: *Mammacarcinom*, Deutsch. med. Wchnschr. **12**:646, 1886.

28. Sauerbruch, F.: *Die Chirurgie der Brustorgane*, Berlin, Springer, 1920.

29. Fink: Quoted by Amburger, Footnote 12.

30. Mayer: *Sarcome du sternum*, J. méd. de Brux. **9**:146, 1904.

31. Lanphear, E.: Removal of Sternum for Cancer with Suturing of the Innominate Vein; *Surg., Gynec. and Obst.* **14**:619-622, 1912.

32. Lockwood, C. B.: On the Excision of Tumours of the Chest-Wall, *Clin. Jour.* **30**:369-374, 1907.

Rixford<sup>33</sup> excised the first rib, clavicle, and sternum, and the patient recovered. Torek<sup>34</sup> excised a portion of the lung, but the patient died from shock. The end-result is not stated for any of the patients who survived the operation.

In five of eleven cases cited by Amburger, in which the lung was resected with the tumor, a cure resulted (Péan,<sup>35</sup> Müller,<sup>36</sup> and Krönlein<sup>37</sup>); but in one (Krönlein<sup>38</sup>) a second lung resection was necessary. The patient died seven years later of further recurrence. Péan's patient was free from recurrence after one year. Krause<sup>39</sup> resected a portion of the lung in two cases of carcinoma. There was freedom from recurrence eight and eighteen months later, respectively. Helfrich<sup>40</sup> performed a lobectomy in one case; but the patient died twenty-four hours later of cardiac failure. One patient operated on by Mikulicz<sup>41</sup> in whom the diaphragm was resected remained free from recurrence for fourteen months. Several other cases are recorded; all the patients eventually died of recurrence. Judging from these results it seems that although involvement of the diaphragm, pericardium, and lung is not a contraindication to operation, the result of operation can probably be regarded, almost without exception, as palliative only.

#### OPERATIVE TECHNIC

The prevention of pneumothorax and combating its immediate harmful effects have been the chief considerations in operating. Great divergence of opinion and of experience has existed with regard to the harmfulness of pneumothorax and of the advantages of differential pressure anesthesia. In the earlier operations, attempts were always made to excise the tumor without opening the pleura, and thus prevent pneumothorax. In twenty-six of Parham's<sup>3</sup> eighty-two cases, the pleural cavity was not opened. When it was opened, obturating the opening with gauze tampons, immediate suture of the pleura, suture of the lung to the edges of the tumor-bearing area, and closure

33. Rixford, E.: Excision of Portions of the Chest Wall for Malignant Tumors, *Ann. Surg.* **43**:35-47, 1906.

34. Torek, F.: Resection of a Large Portion of the Chest Wall for Sarcoma, *Post-Graduate*, New York **21**:335-337, 1906.

35. Péan, J. E.: Quoted by Amburger, Footnote 12.

36. Müller, W.: Eine Thoraxwand-Lungenresection mit günstigen Verlauf, *Deutsch. Ztschr. f. Chir.* **37**:41-49, 1893.

37. Krönlein: Ueber Lungenchirurgie, *Berl. klin. Wchnschr.* **21**:129-132, 1884.

38. Krönlein: Ueber Lungenchirurgie, *Berl. klin. Wchnschr.* **23**:185, 1886.

39. Krause: Quoted by Amburger, Footnote 12.

40. Helfrich: Quoted by Amburger, Footnote 12.

41. Mikulicz: Reported by von Noorde, W.: Zur Operation der grossen Chondrome des Rumpfes; ein Beitrag zur Chirurgie des Zwerchfelles, *Deutsch. med. Wchnschr.* **19**:346-349, 1893.

of the skin flap were the most common methods of combating the harmful effects. Witzel<sup>42</sup> changed pneumothorax into hydrothorax, then aspirated the fluid. Dollinger<sup>43</sup> gradually induced collapse of the lung by admitting air through a small opening in the pleura before the day of operation and Beccherle<sup>44</sup> at the time of resection. Artificial respiration through intubation or tracheotomy was recommended (Doyen,<sup>45</sup> Tuffier,<sup>46</sup> Hallem,<sup>47</sup> Quénu and Longuet,<sup>48</sup> and others). Parham<sup>3</sup> used the Fell-O'Dwyer apparatus in one case, with satisfaction. Then followed Meltzer's intratracheal insufflation, Sauerbruch's and Meyer's differential pressure chamber apparatus, and finally the recognition that a simple intrapharyngeal insufflation can be used with apparently equally good results. Sauerbruch<sup>28</sup> writes that differential pressure is probably never so particularly indicated as in cases of extensive resection of the thorax.

#### PNEUMOTHORAX

In five of ten cases in the Mayo Clinic, the pleura was opened, in all without differential pressure. There were no immediate alarming symptoms in any case; but there was marked postoperative shock in one case and moderate shock in two cases. In the others there were practically no symptoms. In the five in which the pleura was not opened, there was marked postoperative shock in three, and little or no shock, in two.

In the collected cases, the pleura was opened in twenty-four cases, not opened in five cases, and the procedure not stated in six cases. Differential pressure was used in five of the twenty-four cases. There was postoperative shock in one case. There was shock in four of the cases not under differential pressure, and in one in the group of five cases in which the pleura was not opened. Five of the six patients who died as a result of operation had had the pleura opened without differential pressure. Two of these patients showed marked postoperative shock. Three patients died from empyema, one from shock and anuria, one from cardiac collapse, and one three days after operation, cause of death not stated. In eighteen of Lund's cases in which the facts are specified, five operations were performed with differential

42. Witzel, O.: Ein Verfahren zur Beseitigung des akuten nach Penetration der Brustwand entstandenen Pneumothorax, *Centrallbl. f. Chir.* **17**:523-526, 1890.

43. Dollinger: Quoted by Lund, Footnote 5.

44. Beccherle, G.: Condroma costale; ampia resezione toraco-pleurica, guarigione, *Cesalpino, Arezzo* **10**:204-217, 1914.

45. Doyen: Quoted by Amburger, Footnote 12.

46. Tuffier: Quoted by Amburger, Footnote 12.

47. Hallem: Quoted by Amburger, Footnote 12.

48. Quénu, E., and Longuet, L.: Recherches expérimentales et étude critique sur la chirurgie du poumon, *Bull. et mém. Soc. de Chir.* **22**:787-795, 1896.

pressure and thirteen without. One patient operated on under positive pressure and three without pressure had had severe shock. One patient who died from shock was operated on without differential pressure. One patient operated on under positive pressure died the fourteenth day of pneumonia.

Parham states that in forty-one cases in which operation was performed without differential pressure there was little or no disturbance in sixteen, moderate disturbance in ten, and severe disturbance in fifteen. There can be no doubt that severe shock may develop as a result of operation and entirely independent of pneumothorax. This was especially noticeable in Case 9 and in Case 10; both patients were debilitated and had been subjected to wide excision of a large tumor without pneumothorax.

An operation in two or more stages extends the limits of operability and lowers the postoperative shock. Such an operation can be performed under local anesthesia, and if the lung is sutured to the parietal pleura at the first stage, pneumothorax is prevented without the use of positive pressure anesthesia. Such a procedure probably represents the minimum of risk to the patient. Intrapharyngeal insufflation anesthesia seems, however, the simplest and generally the most satisfactory method. Tight closure of the chest is essential. In one case (Case 8) the skin sloughed at the suture line, producing an infection necessitating a secondary plastic operation.

Even following wide excision there appears to be no untoward effect from the absence of ribs and intercostal tissue. Mayer,<sup>49</sup> however, reports a case in which a hernia of the lung followed. Kirschner<sup>49</sup> reports two cases in which, following extensive resection, he sutured a flap of fascia lata from the thigh into the window in the chest wall with good results.

There was one immediate operative death in the Mayo Clinic series (less than 5 per cent.). There were eleven deaths in the eighty-five cases since 1898 (about 13 per cent.).

In Parham's series there were thirty deaths in 103 cases (29 per cent.). The cause of the sixteen deaths in the fifty-five cases in which the pleura was opened was shock in seven, empyema in two, hemorrhage and sepsis in five, "bronchitis" in one, and phenol poisoning in one; the cause of death in the remaining two cases was uncertain.

Of the sixteen patients in the Mayo Clinic series with recurrence, eleven are dead. One of the two patients without recurrence had excision of a sarcoma and cauterization without the opening of the pleura. He has remained symptom-free for eight and one-half years.

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49. Kirschner, M.: Der gegenwärtige Stand und die nächsten Aussichten der autoplastischen, freien Fascien- Uebertragung. *Beitr. z. klin. Chir.* **86**:5-149, 1913.

The other, a patient with fibroma, has remained symptom-free more than nine years. Six of the twenty-one patients had operations for recurrence, one three years after the primary operation; this patient has remained symptom-free one year after the second operation. Of the other five patients one was reoperated on four times, three twice, and two once. Two had been operated on the first time elsewhere.

TABLE 5.—CAUSE OF DEATH IN THE THREE GROUPS

Cause of Death	Mayo Clinic 23 Cases	Hedblom Collected 35 Cases	Lund Collected 27 Cases	Total 85 Cases
Shock .....	..	3	1	4
Pneumonia .....	1	1	1	3
Empyema .....	..	3	..	3
Not stated .....	..	1	..	1
Total .....	1	8	2	11

TABLE 6.—RECURRENCE

Type of Tumor	Mayo Clinic Cases			
	Recovery After Operation	Recurrence	No Recurrence	Result Not Known
Sarcoma .....	12	8	1	3
Carcinoma .....	6	6	..	..
Chondroma .....	1	1	..	..
Fibroma .....	2	1*	1	..
Total .....	21	16	2	3

	Collected Cases			
	Recovery After Operation	Recurrence	No Recurrence	Result Not Stated
Sarcoma .....	18	8	2	8
Carcinoma .....	4	..	..	4
Chondroma .....	5	2**	..	3
Fibroma .....	..	..	..	..
Total .....	27	10	2	15

\*Operation for recurrence; no further recurrence after one year.

\*\* Recurrence in one case following extirpation; end-result not known.

One patient, aged 38, came to the clinic with a history of having had an operation for sarcoma of the lower anterior chest wall at the age of 6 and operations for recurrences at the ages of 27, 36 and 37. He presented himself with a large ulcerating area, but there was no definite tumor. A roentgenogram showed a shadow which was interpreted as metastasis in the lung; microscopic examination showed sarcoma. Cases 12 and 14 are examples of long freedom from recurrence. Case 7 is an example of very rapid malignant growth.



In the thirty-five collected cases, there were twenty-seven postoperative recoveries. The end-results, after one year, are given in twelve cases; in two cases there were no symptoms for two and one-sixth years and seven years, respectively, after operation.

In Parham's series of twenty-five cases of sarcoma, eight patients were free from recurrence from one to five years, and two of seven patients with chondroma were free from recurrence one and five years, respectively.

In the total sixty-five cases, then, in which results were ascertained after one year, only fifteen patients (23 per cent.) remained free from recurrence at the time of the last report. This shows that the tendency to recurrence is great, not only of sarcoma but also of the so-called benign chondroma and fibroma. It may be noted that there was no known recurrence in seven of thirteen cases of chondroma; but there was recurrence in one after six years.

It seems evident, from these considerations, that the large majority of malignant growths of the chest wall may be expected to recur or metastasize after excision, and that the so-called benign growths are liable to do so. It seems equally clear that extirpation of the tumor prolongs life materially in most instances even when the operation is performed late or for extensive involvement or for repeated recurrence.

#### SUMMARY

1. Tumors of the bony chest wall are relatively rare. In 213 cases (61.4 per cent. sarcoma and 18.7 per cent. chondroma) the ribs were primarily involved in 78.7 per cent., and the sternum in 21.3 per cent.

2. Trauma seems to be etiologic in some cases, both with regard to incidence and to malignant degeneration of the benign forms.

3. Pain is the most characteristic symptom and may be present in the case of a benign as well as of a malignant tumor. Pain may be present before the tumor is recognized.

4. Early differential diagnosis of neoplasm and cold abscess, exostosis, aneurysm, and dermoid cyst may be difficult. Preoperative differentiation of a benign or a malignant neoplasm may be impossible.

5. Early radical extirpation offers the best prospect of prolonging life and of cure. Late radical or palliative extirpation, even in the presence of extensive involvement, may result in a relatively long period of freedom from recurrence.

6. Early exploratory thoracotomy is indicated in any doubtful case.

7. Differential pressure anesthesia, while not essential to the successful removal of tumors involving wide opening of the pleural cavity, obviates the risk incident to sudden open pneumothorax, and by preventing a closed pneumothorax may lessen materially the occurrence of postoperative shock, pneumonia, and empyema.

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8. Intratracheal or intrapharyngeal insufflation anesthesia affords an effective means of preventing operative pneumothorax.

9. Shock, pneumonia, and empyema are the common causes of postoperative deaths.

10. Recurrence has been the rule in most cases of malignant tumor; but there may be freedom from recurrence for many years and life may be further prolonged by repeated extirpation of the growth.

#### REPORT OF CASES

Case 1 and Cases 4 to 14, inclusive, are those in which radical extirpation of the tumor was attempted. Case 1 is too recent to be included in the series, but it is classified with Cases 2, 3, and 4 as an inflammatory tumor presenting special difficulties in diagnosis. In



Fig. 1 (Case 303102) —Nonmelanotic melano-epithelioma of manubrium of very rapid growth. The patient had two operations before coming to the Clinic.

Case 15 the patient has been free from recurrence for more than nine years following operation for sarcoma.

CASE 1 (342085).—Mr. J. E. F., aged 47, registered at the Clinic, Nov. 26, 1920, because of a tumor of the chest wall, elsewhere diagnosed sarcoma. About one year before, he had injured his left hand, and was taken to a hospital. While there he had developed night sweats and pain along the right costal border, which had persisted. Later a tumor had appeared, accompanied by soreness in that area. The patient was otherwise in good condition; he had had no increase in temperature, cough or loss of weight.

A dense, rounded tumor was found in the anterior chest wall. The roentgenogram of the chest revealed elevation of the diaphragm. The urinalyses, including Bence-Jones protein test, were negative; the Wassermann test was negative.

December 2, I operated under local and gas intrapharyngeal insufflation anesthesia. Segments of the distal ends of the fifth, sixth, seventh, and eighth ribs and cartilages were removed with the tumor mass. An encapsulated abscess cavity about 10 cm. in its greatest dimension was found over the costal cartilages at the costal margin, lined with granulation tissue and with greatly thickened walls; the ribs involved were necrotic and partly broken down. A tear 1.25 cm. long was made in the pleura; but on account of the positive pressure anesthesia, pneumothorax did not occur. The rent in the pleura was sutured and the skin flap closed tight. The convalescence was uneventful.

The pathologist reported chronic inflammation, with osteomyelitis of the ribs.

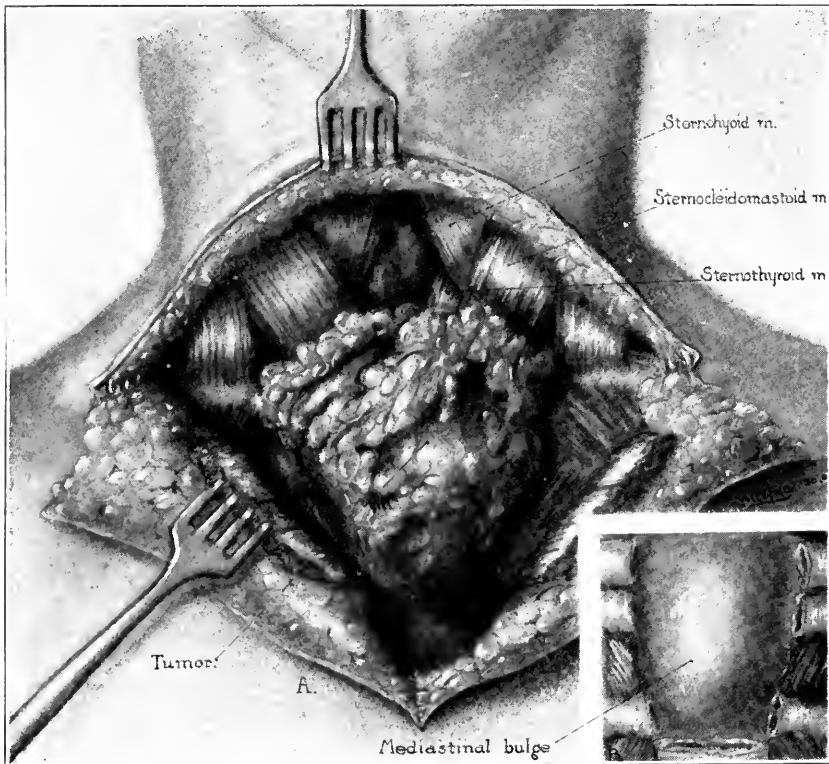


Fig. 2 (Case 303102).—Resection of manubrium for tumor shown in Figure 1.

CASE 2 (330250).—Mr. S. A. R., aged 37, came to the Clinic, Aug. 19, 1920, because of a recurrent growth in the right lower chest wall following an operation elsewhere three weeks before for the removal of a round-cell sarcoma. The tumor had been present about two years, and was described by the patient as firmly fixed, tender, and about the size and shape of an index finger, overlying the rib.

Examination showed a smooth bulging tumor over the fifth and sixth ribs, 10 or 12 cm. in length. The roentgenogram of the chest, the Wassermann test, and other clinical findings were essentially negative.

September 9 under ether anesthesia I resected about 20 cm. of the sixth, seventh, eighth, ninth, and tenth ribs with the entire thickness of the chest wall except a skin flap. There was no marked respiratory embarrassment. The growth was found to have extended through onto the parietal pleura; but the lung itself was free. The wound was closed tight without drainage.

The patient's general condition was quite satisfactory for two days; he then developed bronchopneumonia and died the fourth day. Postmortem examination revealed bronchopneumonia of the right lung and congestion and edema of the left.

CASE 3 (316452).—Mr. R. R. C., aged 48, came to the Mayo Clinic, May 19, 1920, because of a recurring tumor and pain in the right chest wall. In January,

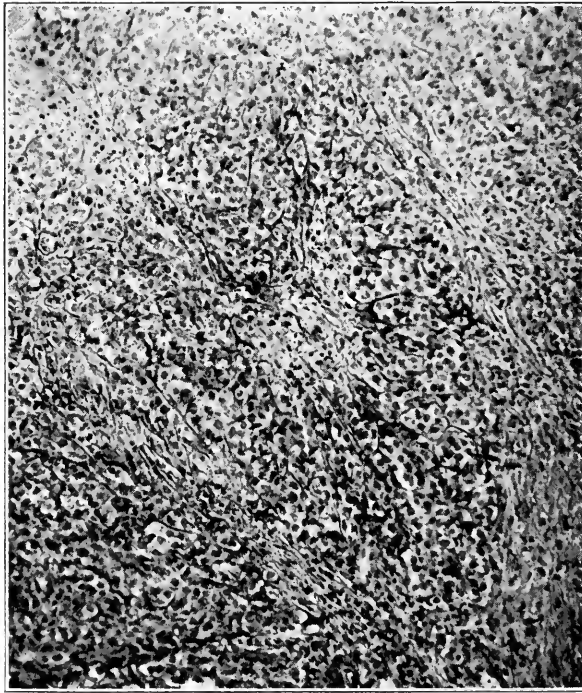


Fig. 3 (Case 303192).—Photomicrograph of nonmelanotic melano-epithelioma of manubrium.

1916, he had been struck in the right side of the back by a piece of lumber, and the injured area remained sore for some time. In 1919, the pain recurred. Roentgenograms five months before examination revealed a tumor involving the right seventh rib, which was removed elsewhere with temporary relief from pain. The patient was cachectic and bedridden.

Examination revealed a tender tumor about 8 by 12 cm. in the region of the seventh rib below the angle of the scapula.

A two-stage radical resection was attempted. The first stage was performed, May 27, 1920. At the second operation, July 1, the malignant infiltration was found to be so extensive, the skin flap being also extensively infiltrated, and the

patient in such poor condition that the radical extirpation was not completed. The patient was sent home for roentgen-ray and radium treatment. The final course in the case has not been ascertained.

CASE 4 (314608).—Mr. F. B., a healthy looking man, aged 20, was examined, May 4, 1920. Six years before he had noticed a swelling of the right anterior portion of the chest just below the clavicle, which had gradually increased in size and which caused a dull ache on exertion. Examination revealed a diffuse

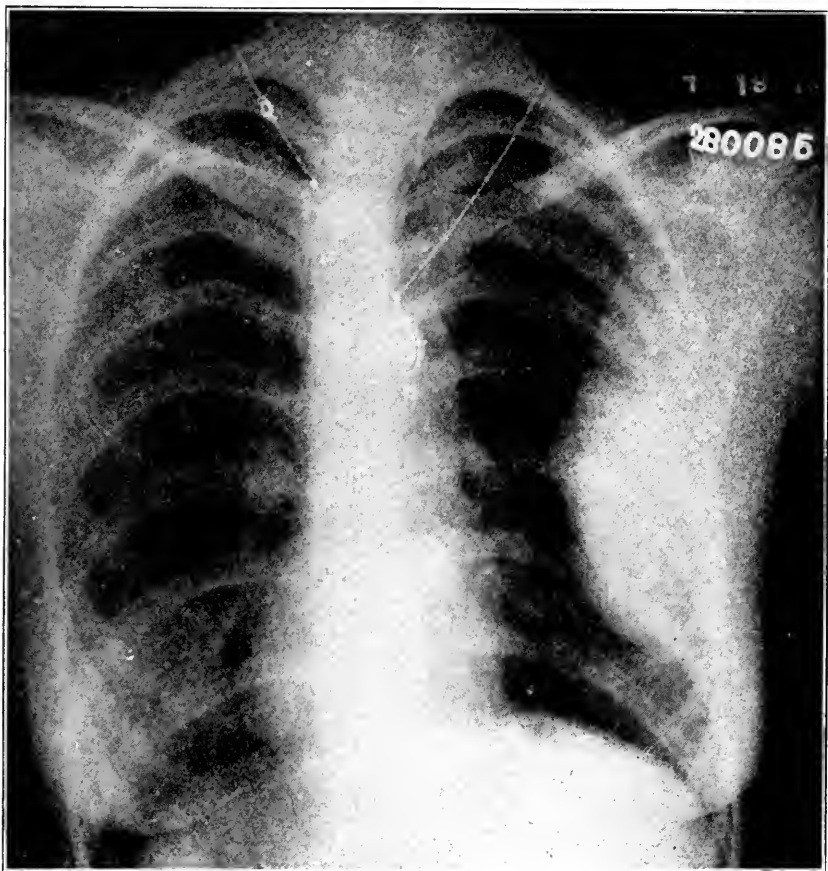


Fig. 4 (Case 280085).—Fibroma encroaching on pleural cavity: superficial tumor very slight.

enlargement involving the area of the upper end of the sternum and the first and second ribs. The Wassermann test, roentgen-ray and fluoroscopic examinations of the chest and sternum were negative.

At operation, May 11, 1920, I resected the sternoclavicular joint and the upper portion of the manubrium. The pathologist reported the condition to be inflammatory, with some periostitis.

There has been no further evidence of neoplasm.

CASE 5 (309624).—Mrs. E. M., aged 53, registered at the Clinic, March 20, 1920. She gave a history of having fallen and struck her chest, about seven months before. Four months after the accident, she had noticed a swelling in the upper part of the sternum, which increased in size but was not painful.



Fig. 5 (Case 280085).—Excision of tumor with ribs and portion of pleura involved; pectoral muscles have been removed.

The upper third of the sternum was swollen and the left axillary gland tender. The roentgenogram was negative.

On exploration, April 13, 1920, I found a bulging at the right sternoclavicular articulation. The manubrium was resected. The pathologist reported periostitis. There is no evidence of tumor ten months after operation.

CASE 6 (313967).—Mrs. J. J. G., aged 36, came to the Clinic, April 28, 1920. She stated that for the last six months she had had a swelling at the right sternoclavicular joint, and recently, swelling above the clavicle. The pain had apparently been aggravated by an infection of the jaw following extraction of a tooth under ether. She had had some dyspnea the last year, but no loss of weight nor other symptoms. A definite diagnosis of sarcoma had been made elsewhere.

There was an indefinite swelling in the region of the right clavicle. The roentgenogram of the chest showed no evidence of metastasis.

Exploration, May 27, 1920, disclosed apparent involvement of the sternoclavicular articulation only. I resected three fourths of the manubrium. The pathologic examination showed periostitis only.

There is no further evidence of neoplasm nine months after operation.

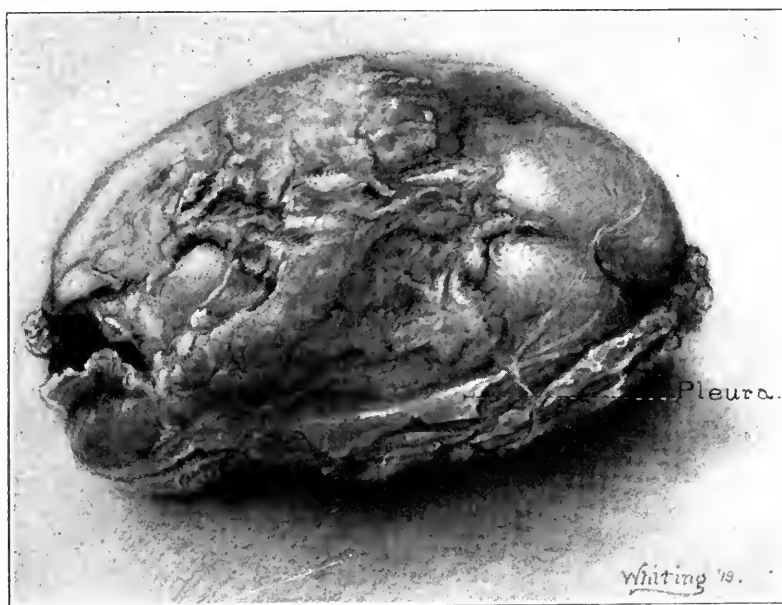


Fig. 6 (Case 280085).—Pleural aspect of tumor with ribs and pleura attached.

CASE 7 (303102).—Mrs. J. C. W., Jr., aged 24, registered at the Clinic, Jan. 16, 1920, because of a recurrent growth at the suprasternal notch. Three years before, a small hard lump had appeared in front of the upper part of the sternum. It grew very slowly until fourteen months before when following a bruise it rapidly grew to about 6 cm. in diameter, but remained movable. This and a recurrent growth had been removed elsewhere, Aug. 19, 1919. The pathologist's report at that time was "a tumor bordering on malignancy but not so yet." Coley's toxin had been administered every two or three days for five or six weeks.

On examination a smooth symmetrically rounded mass, about 6 or 8 cm. in diameter, could be seen and felt over the suprasternal notch (Fig. 1). The roentgenogram of the chest was negative, and the Wassermann test and the usual urinalyses were negative.

Operation was performed, Feb. 5, 1920, under ether anesthesia. A necklace incision was made. The tumor mass seemed encapsulated, but attached to the sternum. I removed it in toto, with the inner extremities of the clavicles, the cartilages of the first and second ribs, and the entire manubrium (Fig. 2). The pleural cavities were not opened. The wound was closed tight. Microscopic examination demonstrated a nonmelanotic melano-epithelioma but no involvement of the manubrium (Fig. 3). The patient's convalescence was uneventful. She had surprisingly little difficulty with movements of the arms or head. During the next three months she received 75,960 mg. hours of radium.

Seven weeks after the operation there were numerous shotlike nodules in the skin over the upper sternum. A gland excised at this time from the left



Fig. 7 (Case 280085).—Photomicrograph of fibroma. Patient is symptom-free one year after operation.

axilla showed nonmelanotic melano-epithelioma. The patient died from recurrence, Aug. 17, 1920, six months after operation.

CASE 8 (280085).—Mrs. J. E. P., aged 24, came to the Clinic, July 15, 1919, because of a tumor on the right anterior chest wall, which had been rather indefinite at first, but had increased in size during the last six months.

The patient was frail, anemic, very nervous, and exceedingly apprehensive. The tumor overlay the third, fourth, and fifth ribs, extending outward to the anterior axillary fold. It was hard, smooth, fixed, and slightly tender. The roentgenogram showed that more than one half of the mass projected inside



the thoracic cavity (Fig. 4). The hemoglobin was 75, the urinary findings normal. The tumor was believed to be either a chondroma or a fibrosarcoma, and a two-stage operation was advised.

At the first operation, July 31, 1919, under ether, I resected the third, fourth, and fifth ribs proximally and distally, and mobilized the tumor. The parietal pleura was thin, showing the lung freely movable underneath. The Halsted operation for amputation of the breast and dissection of the axilla was performed, the axillary glands being enlarged. The lung was sutured to the parietal pleura and the wound closed tightly. The axillary glands proved to be inflamed. The patient was considerably shocked, the pulse reaching 160 two days after the operation. Three hundred cubic centimeters of serous effusion were aspirated the fourteenth day. The tumor mass was removed August 19 under

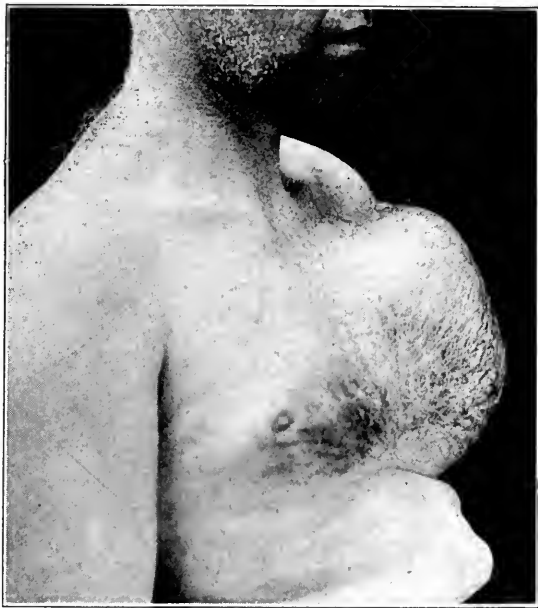


Fig. 8 (Case 273694).—Chondrosarcoma of fifteen years' duration: rapid growth with severe pain last three months.

light ether anesthesia, by opening up the former incision and cutting the pleura and intercostal tissues widely about it (Figs. 5 and 6). The lung was partly collapsed, and the pleural cavity contained about a liter of fluid the color of port wine. There was no respiratory embarrassment nor cyanosis during the operation, which, however, lasted only about fifteen minutes. Microscopic examination demonstrated the tumor to be a fibroma (Fig. 7). A partial collapse of the lung resulted, for which several minor plastic operations were performed, finally completely obliterating the cavity. The patient made a complete recovery.

CASE 9 (273694).—Mr. C. D. S., aged 43, presented himself at the Clinic, June 5, 1919, with a tumor of the left anterior chest wall, about 20 cm. in diameter. Fifteen years before, he had first noticed a small hard lump near the left nipple which grew very gradually up to three months before examina-

tion. Since that time the growth had been comparatively rapid. Pain, which was first felt in the region involved one year before, had lately been so severe that it interfered with sleep. There had been no noticeable loss of weight.

The tumor covered the larger part of the left anterior chest wall (Fig. 8). It was hard, slightly nodular and fixed. The roentgen ray showed a dense infiltration of the whole left pleural cavity. The right pupil was slightly larger than the left and irregular in outline. The hemoglobin was 69; the Wassermann test and the ordinary urinary tests were negative. The diagnosis was osteosarcoma, and excision was advised.

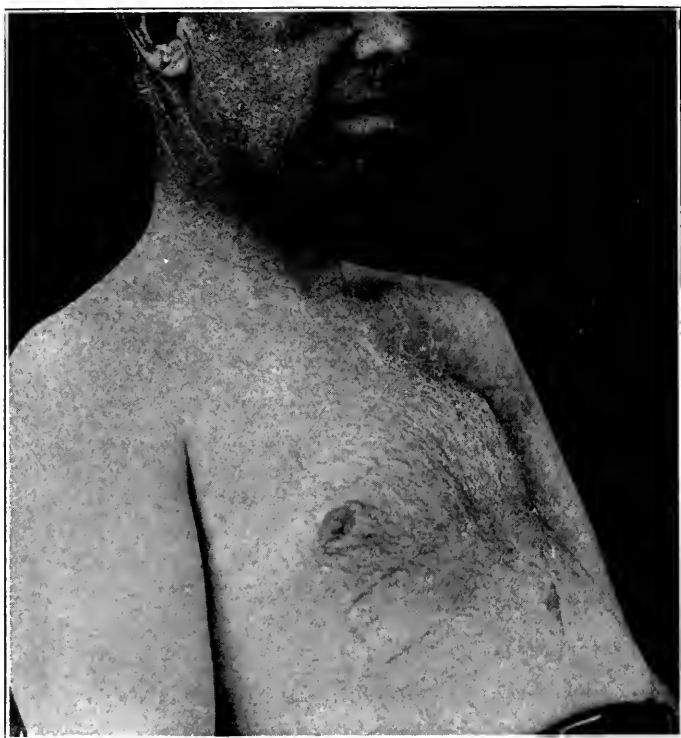


Fig. 9 (Case 273694).—Patient shown in Figure 8, fifty-five days after operation. He died of recurrence thirteen months after operation.

I operated, June 21, 1919, under ether, beginning with an incision as for a Halsted breast amputation. The tumor seemed to be encapsulated. The attachment of the tumor to the chest wall was at least 15 cm. in diameter, involved the pectoral muscles, and the third, fourth, and fifth ribs. After resection of the ribs it was found that the tumor had infiltrated the pleura and pericardium extensively, and apparently also the lung. As much of the tissue as possible was removed. The axilla was dissected and several large bluish soft glands removed. The skin flaps were approximated. Microscopic examination demonstrated the tumor to be an osteochondrosarcoma. The patient was considerably shocked but rallied satisfactorily to warmth and stimulation. The convalescence was uneventful (Fig. 9).

During the next nine months the patient received more than 19,000 mg. hours of radium. He gained weight, and the pain disappeared entirely. In October, he reported for examination. Except for several small serum pockets in the skin flaps, the wound was healed and there was no sign of recurrence. In January, a nodule was excised from the axilla and found to be osteosarcoma. The patient died from recurrence, July 15, 1920, thirteen months after operation.

CASE 10 (269244).—Mr. W. S. C., aged 48, came to the Clinic, April 27, 1919, because of pain and a tumor of the right chest wall. He was thin, weak, anemic, irritable, and apprehensive to the point of hysteria. Two and one-half years before he had developed pain in the right chest which was particularly trouble-



Fig. 10 (Case 269244).—Metastatic adenocarcinoma of lung and breast, primary in suprarenal glands.

some for six weeks, and had persisted more or less since. Following influenza in October, 1918, the pain had become very severe. In February, 1919, a roentgenogram elsewhere revealed a tumor of the right chest wall 5 cm. or more in diameter. At this time the patient had fever which subsided following the extraction of several carious teeth. The tumor first became perceptible two months before examination, and grew rapidly. He had recently had some fever and had lost weight.

Examination showed a tumor of the right upper anterior chest wall, 10 cm. in diameter (Fig. 10). The roentgen ray revealed an extensive intrathoracic

involvement, but the lung appeared not to be involved (Fig. 11). The Wassermann test was negative; the hemoglobin was 40; the urine showed normal findings. The patient refused even to consider operation until radium treatment had been tried. He received, during May and June, 25,400 mg. hours of radium, but the tumor continued to grow, the pain persisted, and the general condition became worse rather than better.

August 7 and August 16 under ether anesthesia I performed a two-stage operation in the hope that if the tumor could be removed radium might be of more effect. The tumor was found to be shaped like a dumb-bell, the connecting

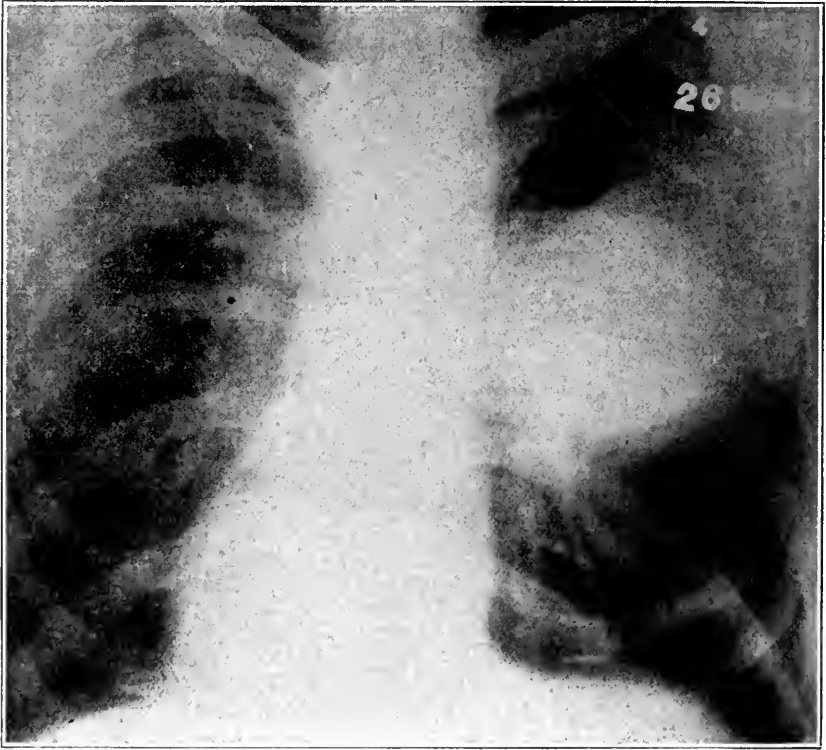


Fig. 11 (Case 269244)—Roentgenogram of adenocarcinoma of lung and breast shown in Figure 10.

mass occupying the third and fourth interspaces, the fourth rib included. The third, fourth, and fifth ribs were resected and the tumor enucleated. The pleura was thickened, the tumor seeming to be encapsulated; there was no pneumothorax. The cautery was applied to the base and a skin plastic operation performed to cover the exposed areas. The microscopic diagnosis was adenocarcinoma (Fig. 12).

The patient developed local recurrence and died six months after operation. Necropsy showed a primary suprarenal growth.

CASE 11 (206257).—Mr. R. O. S., aged 40, presented himself for examination, Aug. 27, 1917, because of a growth on the right chest wall which had appeared

about eighteen months before and had slowly increased in size. The patient did not give a history of trauma; but he had noted soreness in the area involved six months before the tumor was first noted.

The mass was found to be 10 or 12 cm. in diameter and firmly fixed to the anterior chest wall. The Wassermann test was negative. A diagnosis of osteosarcoma was made and excision advised.

Operation was performed Sept. 2, 1917 by Dr. Robinson, under ether anesthesia; the tumor and three involved ribs were removed. A tear was made in the pleura in stripping off the tumor. A cleavage plane was followed; but there

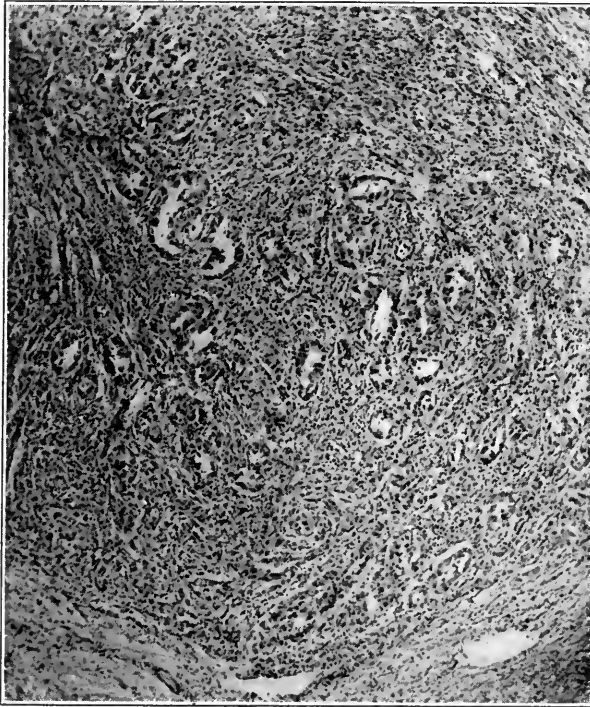


Fig. 12 (Case 269244).—Photomicrograph showing alveolar arrangement of cells in adenocarcinoma.

was question of infiltration of the parietal pleura in one small area. The pathologic report was a round-cell sarcoma. The convalescence was prolonged by infection in the wound, but empyema did not result. The patient had more than 15,000 mg. hours of radium during the six weeks following operation.

In January, 1918, a report was received by letter that the patient had developed weakness and stiffness in the joints four weeks after leaving the Clinic; no further report has been received.

CASE 12 (176942).—Mr. K. F. G., aged 28, came to the Clinic, Nov. 2, 1916, on account of a tumor of the chest wall. Five years before he had fallen some distance and probably fractured one of the lower ribs on the right side at

its sternal end. Two years before examination, he had noted a small mass over this area which grew in a few months to the present size. There had been slight pain and tenderness only during the last few months.

Examination showed a mass at the sixth and seventh right costochondral juncture, which was hard, and immovable, but not tender (Fig. 13). The roentgen-ray examination of the chest, and examinations of urine and of the blood were negative. The diagnosis was chondroma, and operation was advised.

Nov. 6, 1916, Dr. Robinson operated, under ether anesthesia. He attempted to dissect the tumor from the pleura, but a rent was made, resulting in a wide, open pneumothorax, which, however, produced no symptoms. The tumor was removed with sections of the fourth, fifth, and sixth ribs, costal cartilages, and edge of the sternum (Fig. 14). Microscopic examination demonstrated the tumor to be a fibroma. During the patient's convalescence a pleural effusion

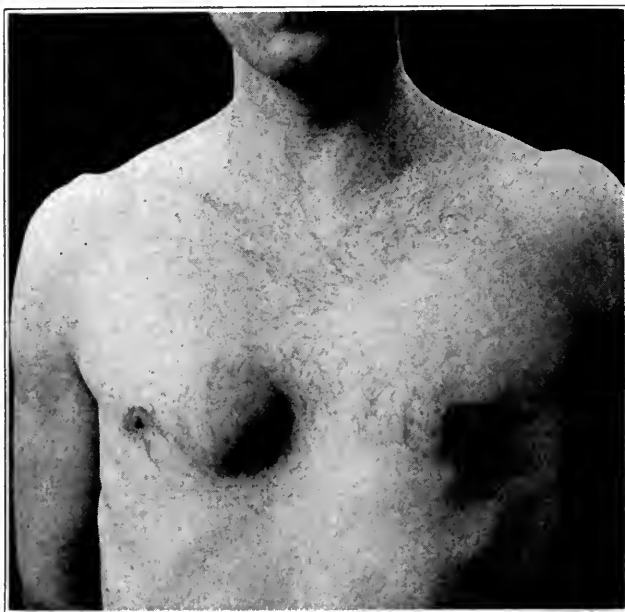


Fig. 13 (Case 176942).—Fibroma of chest wall, Nov. 2, 1916.

developed, which required four aspirations within the first three weeks. There was no fever.

The patient returned to the Clinic in November, 1919, because of a recurrence. He had been quite well and had been working since a few months after the first operation. A bulging tumor about 5 cm. in diameter was felt, and a circumscribed shadow in the roentgenogram at the right cardiophrenic angle suggested a recurrence.

December 1 and 30, 1919, I performed a two-stage operation and found a tumor mass involving the distal end of the fourth rib, the sternum, and the pericardium. The lung was only partly adherent. The tumor mass was removed together with the larger part of the gladiolus and sections of the third and fourth ribs. The tumor lay against the pericardium, but was separated from it without tearing the membrane. The microscopic diagnosis was fibroma.

Convalescence was uneventful except for bilateral suppurative parotitis (Fig. 15). The patient remained well with no sign of recurrence one year after operation.

CASE 13 (129508).—Mr. E. S., aged 47, came to the Clinic, April 24, 1915, because of a recurrent tumor of the anterior chest wall. Seven years before, a horse had fallen on his chest. Three months later a nodule appeared which grew slowly to about 7 cm. in diameter. The growth was removed elsewhere in 1914 and pronounced a chondroma. Recurrence was noted within three months.

On examination at the Clinic the tumor was found to be 12 or 15 cm. in diameter and firmly fixed to the chest wall; the skin was adherent. There had



Fig. 14 (Case 176942).—Fibroma shown in Figure 13; involving the fourth, fifth, and sixth ribs, the costal cartilages, and the edge of the sternum.

been considerable pain. A roentgenogram taken diagonally showed no intra-thoracic involvement.

The first stage of a two-stage operation was performed, April 30, 1915, by Dr. Robinson, under intratracheal ether anesthesia. The third, fourth and fifth ribs with their cartilages were resected. At the second operation, May 4, 1915, the third, fourth, and fifth ribs were resected and the tumor mass stripped from the parietal pleura without rupturing the pleura. The convalescence was marked by a febrile course lasting about two weeks. The microscopic diagnosis was myxochondrosarcoma.

Dr. Robinson operated for local recurrence in April and in July, 1916, and again in April, 1917, removing the second, third, and sixth ribs and the outer

TABLE 7.—CASES REPORTED IN THE LITERATURE

Author	Sex* and Age	Trauma	Duration	Location and Size	Anesthetic	Resection	Pathologic Diagnosis	Methods Contra-pneumo-thorax	Pneumo-thorax	Symp-toms from Pneumo-thorax	Shock	Complica-tions	Results
Amburger <sup>12</sup> (1901)	♂ 17	.....	5 mo.	Sternum; 3 by 9 by 11 cm.	C	Manubrium, first and second ribs	Round-cell sarcoma	Suture and tampon	Double	0	0	.....	Death 3 days after operation
Amburger <sup>12</sup> (1901)	♂ 37	.....	2 mo.	Sternum; goose egg	C	Gladiolus and 3 ribs	Round-cell sarcoma	.....	0	.....	0	0	Death from metastasis 1½ years
Amburger <sup>12</sup> (1901)	♂ 37	.....	8 mo.	Sternum; apple	C	Manubrium, first and second ribs	Spindle-cell sarcoma	Suture and skin flap	Left	0	0	0	No recurrence 2½ years after operation
Amburger <sup>12</sup> (1901)	♂ 22	.....	17 yr.	Pectoral muscle, sternum, and retrosternum; fist	C	Manubrium, second and third ribs	Fibromyxosarcoma	Tampon	Left	0	..	0	Death from hemorrhage 1 year after operation; recurrence size of child's head
Amburger <sup>12</sup> (1901)	♂ 40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Death from empyema 11 days after operation
Amburger <sup>12</sup> (1901)	♂ 30	.....	1 yr.	Behind breast, third to sixth ribs, right; child's head	C	Third to sixth ribs with pleura	Chondroma	Tampon	+	0	..	Empyema	Death from recurrence 1½ years after operation
Amburger <sup>12</sup> (1901)	♂ 3	.....	8 da.	Seventh to tenth ribs, right; fist	C	Eighth to tenth ribs, diaphragm, peritoneum, and abdominal wall	Round-cell sarcoma	Suture	+	0	+	0	Death from recurrence 1½ years after operation
Amburger <sup>12</sup> (1901)	♂ 37	.....	5 mo.	Three former operations; eighth rib posterior, left; walnut	C	Eighth rib; zinc chlorid paste, tampon	Sarcoma (metastatic)	.....	0	.....	0	Pneumothorax 24 hours after operation; tampon	Spinal metastasis (?) after 3 months
Morestin <sup>20</sup> (1902)	♀ .....	.....	weeks	Sternum (breast amputated for sarcoma 7 months before)	...	Manubrium	Sarcoma	.....	.....	.....	..	0	Not stated
Lilienthal <sup>51</sup> (1903)	♂ 48	.....	9 mo.	Seventh and eighth ribs, left; sausage shaped	...	Seventh and eighth ribs with parietal pleura	Fibromyxosarcoma	.....	0	.....	0	.....	Not stated
Slek <sup>52</sup> (1903)	♂ 25	.....	14 mo.	Below right scapula; fist	C	Sixth to ninth ribs and pleura	Sarcoma	Tampon	+	Cardiac collapse	+	.....	Death 2 hours after operation
Slek <sup>52</sup> (1903)	♂ 25	.....	2 yr.	Fifth to ninth ribs, right lower lateral; three fists	C	Four ribs, pleura and diaphragm	Chondrosarcoma	Tampon	+	.....	+	Pleurisy with effusion	Postoperative recovery; result not stated
Negroni <sup>53</sup> (1904)	♂ 21	.....	1½ yr.	Fourth and fifth rib, right mammary region; hen's egg	C	Two ribs with pleura	Giant-cell sarcoma	Tampon	+	.....	..	.....	Not stated
Mayer <sup>50</sup> (1904)	♂ 38	.....	2 yr.	Sternum	...	Three upper ribs and sternum	Sarcoma	.....	Double	.....	..	Empyema	Death from empyema 9 days after operation
Peraire and Lafas <sup>54</sup> (1906)	♂ 32	.....	.....	Third rib right; orange	...	Third rib	Epithelioma	.....	.....	.....	..	.....	Postoperative recovery; result not stated
Isaacs <sup>55</sup> (1909)	♂ 46	.....	3 mo.	Sternum; hen's egg	...	Sternum below second costal cartilage, and cartilages below	Spindle-cell sarcoma	Tampon	+	.....	+	Pneumonia	Recurrence and metastasis 1 month after operation
Sourdille <sup>55</sup> (1909)	♂ 11	.....	13 mo.	Sixth rib, right, 3 by 9 by 11 cm.	...	Entire sixth rib	Round-cell sarcoma	0	+	0	0	0	Postoperative recovery; result not stated
Poulain <sup>56</sup> (1909)	♀ 29	+	2 yr.	Eighth and ninth ribs, left, 30 by 39 by 45 cm.	...	Eighth and ninth ribs, diaphragm (pleura opened)	Fibromyxochondroma	0	+	.....	+	Empyema following drainage	Death from empyema few days after operation
Lamphear <sup>51</sup> (1912)	♀ 61	.....	3 mo.	Sternum	C	Manubrium and parts of clavicle (two-stage operation)	Carcinoma	.....	0	.....	+	.....	Postoperative recovery; result not stated

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	♂ 58	6 yr.	Sixth and seventh ribs, right; weight 2.2 kg. Tenth rib; fist	... Brauer's positive pressure	Sixth to ninth ribs and segment of diaphragm Three ribs	Chondroma Myxoehondroma	..... .....	..... 0	..... .....	Anuria .....	Death 2 days after operation No recurrence 6 months after operation
Lorrain <sup>57</sup> (1912)	♂ 58	8 yr. months									
Hesse <sup>14</sup> (1912)	♂ 57	.....									
Kirschner <sup>19</sup> (1913)	♀ 40	10 yr.	Seventh to tenth ribs; child's head	Brauer's positive pressure	Seventh to tenth ribs; pleura and peritoneum opened	Chondrosarcoma	.....	.....	.....	.....	(Window closed with fascia lata); inoperable recurrence 10 months after operation
Kirschner <sup>19</sup> (1913)	♂ 19	.....	Left and lateral; man's head	Brauer's positive pressure	Entire chest wall	Sarcoma	.....	0	+	.....	(Window closed with fascia lata); recurrence 6 months after operation; 1½ years after operation size of man's head
Richardson <sup>58</sup> (1913)	♂ 26	..... years	Manubrium; recent growth rapid	.....	Manubrium	Chondroma	.....	0	+	.....	Postoperative recovery; result not stated
Baldwin <sup>20</sup> (1913)	♂ 8	..... months	Eleventh rib, right	.....	Eleventh rib, right	Osteosarcoma	Tampon	+	0	.....	No recurrence 7 years
Baldwin <sup>20</sup> (1913)	♂ 32	1 yr.	Right ribs posterior; orange	.....	4 ribs posterior and transverse process vertebrae	Osteosarcoma	.....	Complete	Very slight	0	Near death 10 months after operation
Baldwin <sup>20</sup> (1913)	♂ 34	.....	Anterior ribs, left after breast amputation	.....	Ribs	Carcinoma	Tampon	+	Slight	0	Not stated
Fort <sup>29</sup> (1913)	♂ 11	8 mo.	First rib and clavicle; walnut	E	First rib, clavicle, manubrium (recurrent)	Osteosarcoma	.....	0	0	.....	No recurrence 6 months after operation
Rigollot-Simonnot and Hugot <sup>60</sup> (1913)	♂ 32	8 mo.	Seventh and eighth ribs, 9 by 10 by 13 cm.	C	Seventh and eighth ribs and diaphragm; suture of lung to parietal pleura	Chondroma	Suture lung	Total, intentional	.....	.....	Three secondary operations for recurrences; patient working 3½ years after first operation
Becherie <sup>44</sup> (1914)	♀ 4	1 yr.	Fourth and fifth ribs, right; egg	C	Fourth and fifth ribs with intercostal space	Chondroma	0	Induced	0	0	Not stated
Lejars <sup>19</sup> (1914)	♂ 40	6 yr.	Xiphoid; 4 to 5 in.	.....	Tumor with xiphoid	Sarcoma	.....	.....	.....	.....	.....
Lejars <sup>19</sup> (1914)	♀ 42	3 yr.	Eleventh rib, lower left; 6 to 8 in.	.....	Eleventh rib, pleura, and diaphragm	Chondroma	.....	+	.....	.....	Excision of recurrence 6 months after operation; second recurrence; final result not stated
Outland and Clendening <sup>61</sup> (1915)	♀ 56	16 yr.	Ninth and tenth ribs, right; 4 to 5 in.	Gas and E	Ninth and tenth ribs and pleura	Round-cell sarcoma	.....	+	.....	.....	.....
Lilienthal <sup>62</sup> (1917)	♀ 19	6 mo.	Sixth and seventh ribs, right	E and pharyngeal positive pressure	Sixth and seventh ribs and intercostal space	Round-cell sarcoma	Intrapharyngeal insufflation	+	0	.....	Postoperative recovery; final result not stated
Meyer <sup>63</sup> (1917)	♀ 51	.....	Below right breast	Intratracheal pressure	15 to 20 cm. of 4 ribs and chest wall; Kenyon's thoracic drain	Endothelioma	Intratracheal	0	.....	0	Not stated
Merlet <sup>64</sup> (1918)	♀ 62	1½ yr.	Right ribs, lower lateral; weight, 4.5 kg.	E, apparatus of Ombredanne	Fifth to seventh ribs; cartilages to midaxilla	Sarcoma	.....	+	0	.....	Postoperative recovery; final result not stated

\* In this column ♂ represents male and ♀ female.

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left third of the sternum. In 1916 the patient had five roentgen-ray exposures, and in 1917 two exposures, at intervals of one month. Further roentgen-ray treatment was strongly recommended when the patient was discharged in 1917.

In May, 1919, there was a rapidly increasing recurrent growth for which operation was performed elsewhere in December, 1920. The patient died shortly after operation.

CASE 14 (108482).—Mr. P. B., aged 29, came to the Clinic, June 18, 1914, because of pain in the left chest. In 1911 on two occasions five months apart he had sustained rather severe injury to the left chest, probably fracturing a rib at the time of the first injury. Except for constant residual soreness, he had had no symptoms until six months before coming to the Clinic, when he was seized with sudden acute pleuritic pains in the left side. Six aspirations performed at that time were negative, but a month later 5 quarts of bloody

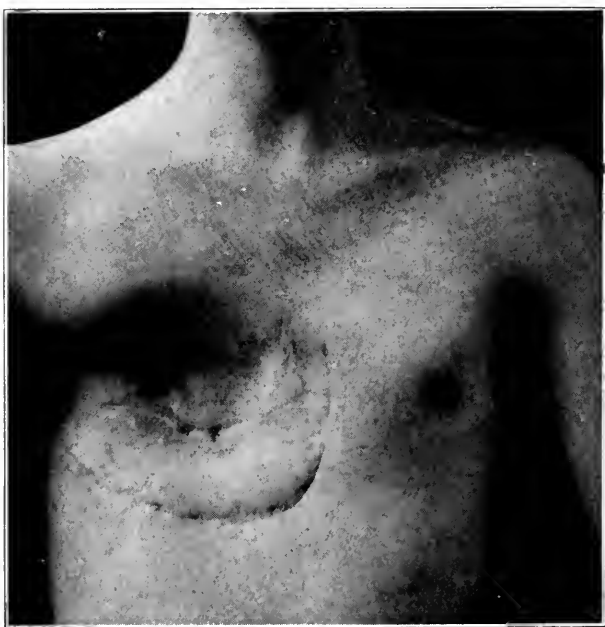


Fig. 15 (Case 176942).—Two and one-half months after operation for recurrent fibroma involving the fourth rib, the sternum, and the pericardium.

fluid were withdrawn, following which the symptoms cleared up, except for a persistent soreness.

Examination revealed a thickening over the fourth rib anteriorly, which was believed to be callus and thickened pleura. Three months later the patient was reexamined with essentially similar findings. July 2, 1917, he returned with a hard, immovable tumor seemingly about 8 cm. in diameter, which had developed during the last four or five months into what had been considered a callus. He had lost 30 pounds in weight, and had experienced soreness and occasional sharp pain in the left chest.

Operation was performed, July 19, 1917, by Dr. Robinson under intratracheal ether anesthesia. The ribs involved were resected, and a tumor mass about 12

cm. in diameter was dissected from the mediastinum and pleura in what seemed to be a definite tissue plane, but it was broken into, and a small piece removed separately. The pathologic diagnosis was mixed oval-cell and spindle-cell sarcoma. The patient received 6,950 mg. hours of radium during 1917, and later returned repeatedly for roentgen-ray treatment and observation. He remained in good health, and there was no sign of local recurrence. The large cavity left by the tumor was reduced to a narrow sinus. In October, 1920, he returned complaining of severe pain in the right shoulder and arm. There was no local sign of recurrence; the roentgenogram revealed evidence of an old pleurisy in the chest, and metastasis in the cervical spine.

May 18, the patient again presented himself at the Mayo Clinic. The pain in the arm and shoulder had subsided following radium applied near the spine through a stab wound (treatment elsewhere). He now complained of pain and weakness in the right leg. Roentgen-ray examination revealed no evidence of metastasis in the lumbar spine. Roentgenograms of the cervical spine showed the same conditions as before. His weight was normal and his general condition good.

CASE 15 (52555).—Mr. A. L., aged 63, came to the Mayo Clinic, May 3, 1911, because of a recurrent tumor of the right chest. He had been operated on for a similar growth the previous December. There was no history of pain or loss of weight, and his health otherwise was good.

The roentgenogram revealed a thickened mediastinum.

The patient was operated on May 5; the tumor was excised and the base cauterized. The pathologist reported sarcoma. The patient left the hospital within a few days of operation and was dismissed May 31, with his wound granulating and in good condition. Occasional reports indicated that he was having no further trouble. In the last report, December, 1920, he stated that his health was very good and that there was no sign of a recurrence of the tumor.

# A STUDY OF RESECTION OF THE PYLORUS FOR GASTRIC ULCER

REPORT OF CASES\*

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MARSHFIELD, WIS.

The results of a study of the effect of the loss of function of the pyloric antrum on gastric digestion, and the establishment, if possible, of the greater curative influence of pyloric resection in gastric ulcer as compared with methods less radical, will be considered in this article.

In such a discussion, the still largely unsettled questions of pyloric function, pyloric control, antral function, gastric mobility and acidity are necessarily often intertwined with the equally debatable questions on the causes of gastric ulcer, its chronicity, its malignant tendency and its curability by purely medical measures, or by indirect or direct surgical procedures.

As it is evidently impossible to treat exhaustively all of these points within the scope of this paper, I shall merely allude to some of them, discuss others briefly and take up exhaustively such phases of the problem as would seem to suit best the purposes in view.

It may be well at the outset to recall points in the anatomy, physiology, and pathology of the stomach and to arrange again before our minds certain accepted facts and theories, and to have them ready for use in this discussion so that we may understand one another thoroughly in the use of terms, phrases, etc.

## ANATOMY, PHYSIOLOGY AND PATHOLOGY OF THE STOMACH

The pylorus, or muscular ring interposed between the stomach and the duodenum, is often likened to a gate keeper regulating the egress of food from the stomach into the duodenum, and guarding against its possible regurgitation into the stomach. A certain intelligence as to when food should leave the stomach and a selective ability, deciding what should pass first and what last, has been ascribed to the pylorus, and much has been said and written on the function of this highly specialized mechanism. Until recently the theory of "acid control" of the pylorus had been most generally accepted. This theory assumes, and it was creditably substantiated by numerous experiments on animals, that as soon as the acidity of the gastric contents reached a

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\* From the Marshfield Clinic.

\* Read before the Tenth Councilor District Medical Society, Eau Claire, Wis., December, 1920.

certain degree of concentration on the gastric side, the pyloric mechanism would automatically be released. The pyloric ring would relax and permit the properly prepared food to be driven out of the stomach and to enter the duodenum. It was further assumed that the acid contents striking the mucous membrane of the duodenum, which on account of the more or less constant presence of bile and pancreatic secretion are always alkaline, would reflexly release another mechanism on the duodenal side, resulting in a contraction of the pyloric ring, thus closing the pylorus and shutting out further acid material, until the first amount had been disposed of and rendered alkaline, through the admixture of bile and pancreatic juice. This being accomplished, the



Fig. 1.—Stomach of boy, aged 12, showing absence of fold of mucous membrane at lesser curvature.

phenomenon would repeat itself *ad infinitum*, until the supply of gastric contents was exhausted, when physiologic rest would ensue. It must be admitted that the theory is attractive and very plausible, indeed, and having been supported by numerous animal experiments has been the almost universally accepted theory of "acid control" of the pyloric sphincter. Observations from various quarters of the medical world, however, have brought out a number of facts that could not easily be fitted into the form of this conception. Thus anatomists have demonstrated in the opened stomach a series of longitudinal mucous and mus-

cular folds, running from the cardia, parallel to and along the lesser curvature, and terminating at the pylorus. They appear like longitudinal furrows or grooves (Fig. 1). The quite regular occurrence of these folds suggested a purpose and a special function. Waldeyer was one of the first accurately to describe these grooves, and called them the "Magenstrasse" or canalis gastricus. Through animal experimentation, the fact was brought out that by a peculiar infolding of these longitudinal folds, a canal or gutter would form, that was thereby distinctly separated from the main cavity, and that through this canal the stomach would empty itself into the duodenum, and that fluids could be transported directly from the esophagus to the duodenum, without intermingling much with the other gastric contents. As proof, animals were fed a full meal, then they were made to drink colored water after which they were examined. No, or but little, coloring matter was found in the gastric cavity, while the duodenum was filled with it. It seems like a wise arrangement too, for a glass of water taken within half an hour or an hour after a meal, if deposited in the stomach itself, would greatly lower the temperature of the gastric contents, dilute its juice and perceptibly suspend digestion for a time. In this way, however, and through the function of the canalis gastricus described above, water would at once be shot into the duodenum. It is a fact, not generally appreciated, that fluids are mainly absorbed in the bowels and that the stomach itself does not absorb liquids. While we thus cannot help admiring this wonderful arrangement, it incidentally casts a shadow of doubt on the theory of strict "acid control" of the pyloric sphincter. In the October issue of the *Archives of Internal Medicine* there are reported the investigations of McClure, Reynolds and Schwartz, that are very apropos in this connection. The action of the pyloric sphincter was studied by means of the fluoroscope, the barium meal and the duodenal tube. When the tip of the inserted duodenal tube was seen to be at the pylorus or in the duodenum, acid or alkaline fluid was injected through the tube and deposited at will in the antral, or prepyloric portion of the stomach, or in the duodenum, and the action of the fluids on the pylorus was watched. The authors come to these important conclusions: Contractions of the motor part of the stomach go on regularly; and as soon as food is introduced, the emptying of the stomach takes place almost immediately, while ingestion of food still goes on. The degree of acidity plays no important part in the motor mechanism of the stomach. Acids deposited on the gastric side do not close the pylorus, in short, the pyloric mechanism is dependant neither on the presence nor on the absence of gastric acidity. These experimental observations studied in man go far to contradict the

deductions, drawn from similar experiments on animals, and it must be admitted make the theory of acid control of the pyloric sphincter untenable.

The gross anatomic divisions of the stomach are the entrance, or cardia; the main portion, or fundus; the smaller pyloric portion, or antrum, and the pylorus, itself. Roughly speaking the antrum is the main muscular and propelling portion—the gastric motor—the fundus is the food reservoir and secreting area, where the acids of the gastric juice are mainly elaborated.

I shall dwell more minutely on the anatomic arrangement of the stomach, its complicated motor function, and shall combine with this consideration a few general deductions that are not only of theoretical but also of practical interest. The *canalis gastricus*, spoken of before, and formed by about four distinctly protruding longitudinal folds of mucous membrane running along and parallel to the lesser curvature of the stomach, is an undisputed entity, recognized by anatomists generally. While the gastric mucosa is distributed rather abundantly and in unsymmetrical arrangement all over the stomach, with a very loose, movable and gliding attachment to the submucosa, the mucous folds forming the *canalis gastricus* are arranged with unerring regularity, as described above, and are much more closely attached to the submucous surface, permitting of but limited shifting and gliding. This more rigid attachment to the submucosa is of importance. When the gastric motor—the antrum—is in action, these mucous ridges form a canal, through the folds of which the liquid portion of the gastric contents sifts and along which it is transported to the pylorus. The astonishing frequency with which gastric ulcers occur in this location was made the subject of minute study by Bauer.<sup>1</sup> Twenty-nine single and six multiple gastric ulcers were studied consecutively and their location schematically drawn upon the outline of an opened stomach, superimposing one sketch upon the other. The aggregate of these sketches gave a composite picture of the preponderance of the location of these ulcers. A study of these drawings as a whole showed that the location of these lesions was limited entirely to the region of the lesser curvature with occasional encroachments on the posterior and anterior wall, leading the author to the conclusion that gastric ulcers originally occur only on the lesser curvature. The remainder of the gastric surface seems absolutely free. Looking at the drawing still closer, a distinct grouping of the lesions is apparent even in this limited area, one group being at, or near, the pylorus, the other, distant from the pylorus, nearer the cardiac orifice.

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1. Bauer, H. K.: Ueber Lokalisation und Entstehung der Magengeschwüre, Deutsch. med. Wchnschr. **41**:1136 (Oct. 7) 1920. Das Lokalisationsgesetz der Magengeschwüre etc., Mitt. a. d. Grenzgeb. d. Med. u. Chir. **32**:217, 1920.

A satisfactory elucidation of this phenomenon is highly instructive, but requires a short review of what is generally known of the genesis of gastric ulcer. It must be distinctly understood, and it is generally conceded, that erosions and defects of the gastric mucosa may occur anywhere in the stomach, are probably very frequent and are no doubt brought about in numerous ways, chemical, mechanical, thermic, or neurogenetic, but that they almost universally heal promptly and completely. It was probably Ashoff<sup>2</sup> who, as one of the first, insisted upon a distinct separation of the causes of these first erosions or defects, from those causes that hinder the healing of these erosions and permit the development of true gastric ulcers out of these first lesions. "A theory that aims to explain gastric ulcer in its origin must under all circumstances take a decided position to this question and explain why a usually healing defect does not heal."

At present two theories are entertained. One, the mechanical theory, adhered to generally in this country and England and accepted by Ashoff in Germany; the other, the spasmogenic theory of von Bergmann. The latter and his school attribute the formation of mucous defects to muscular spasms of the mucosa, resulting in necrotic areas, dependant upon a neurosis of the vegetative nervous system; an allusion to, and a practical application of, the vagotonia and sympathicotonia of Eppinger and Hess. The former, the mechanical theory, insists not so much upon the reasons for the development of the initial lesion, but offers mechanical points of view in explanation of the perpetuation of the first lesion and thus of gastric ulcer genesis. Gastric ulcers are peptic ulcers, and as such, are inseparable from the presence of hydrochloric acid. Assuming the occurrence of an erosion or defect anywhere in the gastric mucosa, the defensive mechanism of the stomach causes an infolding and overlapping of the very loose mucous membrane, thus covering the erosion and excluding it from the general gastric cavity. It is thereby safe-guarded from the digestive action of the gastric juice, and speedy healing of the defect is permitted. The loosely attached mucosa and the localized spasmodic contractions of the musculature of the mucosa constitute the saving mechanism. If, however, such a lesion is located at the pylorus in the *canalis gastricus*, owing to the firmer attachment of the mucous membrane in this region, no such overfolding, and exclusion and protection of the lesion from the general cavity of the stomach is possible. Far from being protected from the baneful influence of the acid, the *canalis gastricus*, on the contrary, forms the path through which the liquefied and acid gastric contents must pass, and any existing lesion is constantly

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2. Ashoff: Ueber den Engpass des Magens, Mitt. a. d. Grenzgeb. d. Med. n. Chir. 28:1918.



bathed and subjected to the irritating effect of the acid, and its healing deferred, if not totally prevented. Thus the universal localization of gastric ulcer at the lesser curvature is directly dependent upon, and the result of, mechanical or anatomic functional conditions. That the pyloric region should be an especial spot of predilection is apparent, when the impinging effect of the acid stream against the resisting pylorus and the irritation of frequent muscular contractions are considered. The frequency and grouping of ulcers near the pylorus are thus accounted for. The grouping of lesions distant from the pylorus can similarly be explained. "Long ago, physiologists have spoken of a functional division of the stomach cavity into two portions. Van Helmont as early as 1652 spoke of a functional difference between the cardiac and the pyloric portion. Beaumont, 1834, while observing his historic case of Alexis St. Martin, the Canadian hunter, saw a contraction of what he called the sphincter of the pyloric antrum dividing the stomach at about its middle into two portions. Similar observations were recently made by Moritz and K. Sick, whose accurate measurements of the differential intragastric pressure, from 2 to 5 cm. in the fundus and 50 cm. in the antrum, are especially interesting and tend to suggest a two part division and a fundamental difference of the function in these two parts."

From these observations one is forced to the conclusion that at regular intervals a contracting muscular ring divides the stomach, temporarily at least, into two separate pouches, the fundus and the antrum, or this difference in intragastric pressure could not exist. What roentgenologist has not seen spastic contractions simulating an hour-glass stomach? Concurring observations were made by Ashoff on soldiers during the recent war, when necropsies were performed immediately after death. He frequently found a functional narrowing between the antrum and the stomach, from one to several centimeters in width. He arrives at the conclusion that these "physiologische Engen" or isthmus formations represent regularly recurring functional conditions of the stomach, purporting a gradual sorting of the gastric contents and the further retention in the fundus of food particles, more difficult of digestion. As the pyloric antrum contains only liquid food and the fundus the coarse material, it would appear that it is the function of the isthmus formation to prevent the entrance of coarse particles of food into the antrum, and also the return of liquids already acted upon into the fundus. "Functionally considered, the isthmus ventriculi holds a similar relation to the central portion of the stomach, as does the pylorus to the whole stomach. Both represent physiologic narrows, with the mechanism of egress and ingress as their main function." Both come

in transverse contact with the *canalis gastricus*, there causing temporary physiologic retention of acid fluids and thus explaining the transformation of first defects into chronic ulcers and of the grouping of ulcers in these regions of predilection.

The estimation of the degree of acidity of the gastric contents after ingestion of one of the usual test meals, at one time, formed a very important item in the study and differential diagnosis of stomach diseases; but of late it has been considered of rather minor importance, and no doubt justly so, on account of the extreme variability of the results obtained. While it is true that the secretion of hydrochloric acid in the fundus is mainly due to the stimulus of the food ingestion, it is also true that acid secretion is enhanced or retarded by many psychic influences, such as anxiety and fear, which often prevail at the time these examinations are made, and they cannot help modifying the amount of gastric secretions, one way or another. The results are therefore unreliable, often of no value. The prevailing methods of examining the gastric contents, from thirty minutes to one hour after ingestion of food, gives very inaccurate results as shown by Rehfuß, by the use of the method of fractional determination of gastric acidity. In a recent article by Wilensky,<sup>3</sup> the author concludes that the height of acidity is not always reached at a definite period after ingestion. By the method of fractional determination it was shown that the greatest concentration of acids may be reached long before the elapse of one hour, and as late as three hours after ingestion. Thus, the older method of determining the acidity after a set time cannot help leading to erroneous conclusions. Yet to ignore entirely the methods of acidity determination would probably be equally wrong, for it must constantly be borne in mind that the very presence of acid is probably the most determining and influential factor in the genesis and chronicity of chronic gastric ulcer. Peptic ulcers and gastric acidity are practically inseparable. While gastric ulcers, without acidity, have occasionally, though rarely, been observed; yet such ulcers must be considered an impossibility unless acid was present at some time during their development. Peptic ulcers are found only in such regions as are accessible to the action of gastric juice, i.e., in the esophagus, stomach and duodenum, and in the jejunum, where normally alkalinity prevails, they are seen only after gastro-enterostomies. "No peptic ulcer is ever found in the jejunum unless it be after a gastro-enterostomy," says Shur, nor has a peptic ulcer in the jejunum ever been found after an operation was performed for cancer, in which condition hydrochloric acid is usually absent.

3. Wilensky, A. O.: *The Disturbances of Acid Secretion, etc.*, Surg., Gynec. & Obst. **26**:506 (May) 1918.

The secretion of hydrochloric acid we know is confined to the fundus of the stomach, yet from the researches of Edkins <sup>4</sup> it seems probable that the activity of the glands of the fundus is stimulated and dependent upon a substance which he was able to extract, by means of a 5 per cent. dextrin solution, from the mucous membrane of the pyloric portion of the stomach, the antrum. This substance, known as "gastrin," when injected intravenously, is able to produce acid secretion in the fundus. An extract with a similar action could not be obtained from the mucosa of the fundus, nor would a mere watery extract of the antrum mucosa produce "gastrin." In 1906, Edkins elaborated his discovery by finding that besides dextrin, solutions of glucose, peptone, glycerin and 0.4 per cent. solution of hydrochloric acid also were able to extract the gastrin from the mucosa of the antrum while no such substance could be obtained from the fundus. In 1909, Edkins and Tweedy <sup>5</sup> were able to prove the very suggestive fact, that the above mentioned substances, dextrin, glucose, peptone, glycerin, and 0.4 per cent. solution of hydrochloric acid are absorbed only in the antrum and duodenum, never in the fundus, and that through these the secretion of gastric juice was activated. From these observations we must be profoundly impressed with the enormous importance of the pyloric portion of the stomach, especially as to the secretion of hydrochloric acid. And this fact should be remembered, when we come to discuss the results of resection of the pyloric portion of the stomach.

From the experiments of Edkins, we might conclude that with the removal of the pylorus and antrum a complete inhibition of the secretion of gastric acidity would result; but this is not necessarily so, for we know that besides the chemical action of gastrin, there are other causes that stimulate gastric secretion. I already have referred to the effect of psychic influences. Thus, appetite, the smell, sight and taste of food, and the process of mastication produce nerve effects that stimulate gastric secretion without the aid of gastrin. Yet, that by far the greater stimulus is derived through the gastrin obtained from the antrum is made probable by the fact that simply gastro-enterostomized patients later show but a slight diminution of their preoperative acidity, while after pyloric resection, the acidity is almost lost entirely. The primary slight reduction of acidity after gastro-enterostomy, often only temporary, is therefore due more to the neutralizing effect of the alkaline bile and pancreatic juice, than to any effect the gastro-enterostomy may have on excessive acid formation or through better drainage.

Speaking of better drainage, it is now a universally recognized fact that the ostium of a gastro-enterostomy in nearly all cases of gastric ulcer, not accompanied by a certain degree of pyloric stenosis, becomes

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4 Edkins: *Proc. Roy. Soc. London*, 1905.

5. Edkins and Tweedy: *J. Physiol.* **38**:263, 1908-1909.

ineffective in from one to several months, the food current again seeking its former well worn path through the pylorus. This the fluoroscope demonstrates definitely. That a goodly number of gastric ulcers are permanently, and a certain number temporarily, cured by gastro-enterostomy cannot be gainsaid; but this is mainly the case, when the ulcer is at, or very close to, the pylorus. For in the ulcer near the pylorus, we must expect a certain degree of pyloric stenosis and with it food retention. A properly executed gastro-enterostomy then will and does do wonders. It obviates food retention and puts at rest the pylorus and ulcer area, and the results are very satisfactory indeed. But how it can favorably and permanently influence the healing of the nonstenosing ulcer at a distance from the pylorus is beyond my comprehension. By ulcer at a distance from the pylorus, I mean the one located 3 or more centimeters away from the pyloric ring, toward the cardia, at the site of the functional narrowing of Ashoff, the pyloric isthmus. Here a gastro-enterostomy neither diminishes the acidity, nor promotes motility; in fact, the latter is made worse. A nonfunctioning gastro-enterostomy can only impede, never enhance, the motor mechanism, and as the new gastro-enteric stoma narrows, through nonuse, the reduction of acidity and the neutralization by bile of the gastric content becomes correspondingly less effective. Experience shows that the gastric acidity is often increased postoperatively. The recurrence of gastric distress and formation of new ulcers under such circumstances is not infrequent. It thus seems that not better drainage, but a sufficient lowering of the acidity, caused by the admixture of bile and pancreatic juice, is the guiding principle of the operation of gastro-enterostomy, and that the degree of its success depends upon the permanency with which the access of bile to the gastric contents is assured. Sippy's medical treatment is based upon this principle of lowered gastric acidity, and his method aims at continuous neutralization of the gastric juice.

Thus it would appear, that unless through our operative work we can insure permanent reduction of gastric acidity we cannot hope definitely to cure our ulcer patients, and it is admitted authoritatively that gastro-enterostomized patients frequently suffer again from hematemeses and recurrence of ulcer formation.

For some time past we have been impressed at the Marshfield Clinic with the necessity of doing more radical and aggressive work in stomach surgery, and we have for two years resorted to resection of the pylorus and gastric antrum in dealing with chronic gastric ulcers. It was, therefore, with considerable interest that I read an article by Schur and Plaschkes<sup>6</sup> on the "Importance of the Function of the Pylorus in Stomach Surgery." The authors' work dates back one year, and they

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6. Schur and Plaschkes: Die Bedeutung der Function des Antrum Pylori für die Magen Chirurgie, Mitt. a. d. Grenzgeb. d. Med. u. Chir., **28**:795, 1915.

report a series of six thoroughly studied and reexamined cases. All were undoubted instances of chronic gastric ulcer as shown by operation. The operation performed was a resection of the pylorus and antrum with a posterior gastro-enterostomy, a Billroth II operation (Figs. 2, 3 and 4). Case 1 was examined six months after operation; Case 2, twelve months; Case 3, eleven months; Case 4, six months; Case 5, five months and Case 6, three months after operation. In each case, the chemical examination of the stomach contents showed a low total acidity, never above 20, and complete absence of free hydrochloric acid and very prompt emptying of the stomach. In some instances, the emptying was described as exceedingly rapid. All patients reported

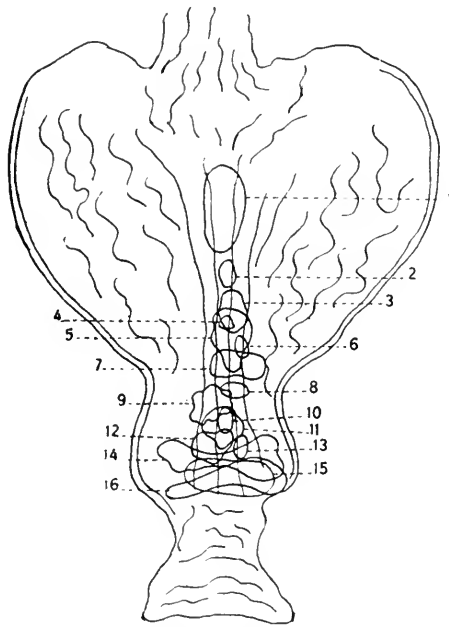


Fig. 2.—Composite illustration of location of single gastric ulcers in sixteen cases (Shur and Plaschkes, Footnote 6).

complete health and normal digestion. This led me to look up our own cases. I was able to reexamine nine unselected cases in which a pylorotomy had been performed, the reports of which cases are presented briefly herewith:

#### REPORT OF CASES

CASE 1.—A. K., a farmer, aged 61, had a large indurating and perforating ulcer near the pylorus. Microscopic examination later proved this to be a cancer. The stomach showed delayed emptying. The Ewald test revealed: total acids, 50; free hydrochloric acid, 28. A Billroth II operation was performed Jan. 2, 1919. He was reexamined Oct. 30, 1920. The Ewald test revealed: total acids, 14; free hydrochloric acid, 0, and lactic acid, 0. Fluoroscopic examination demonstrated delayed emptying, six hours. The patient feels well

and is able to work moderately. He has had two attacks of vomiting within two months. He appears healthy, but suffers from slight constipation.

CASE 2.—Mrs. W. H., housewife, aged 56, had an ulcer scar on the lesser curvature, causing an hour-glass stomach, and a perforating second ulcer on the posterior wall. She suffered from vomiting and inability to eat. The Ewald test revealed: total acids, 45; free hydrochloric acid, 25. A sleeve resection was performed April 16, 1919. The patient was reexamined Oct. 30, 1920. The Ewald test revealed: total acids, 19; free hydrochloric acid, a trace. Fluoroscopic examination demonstrated emptying in three hours. The patient has gained 15 pounds in weight. She looks well, is able to do her work, has no pain, and bowel movements are regular.

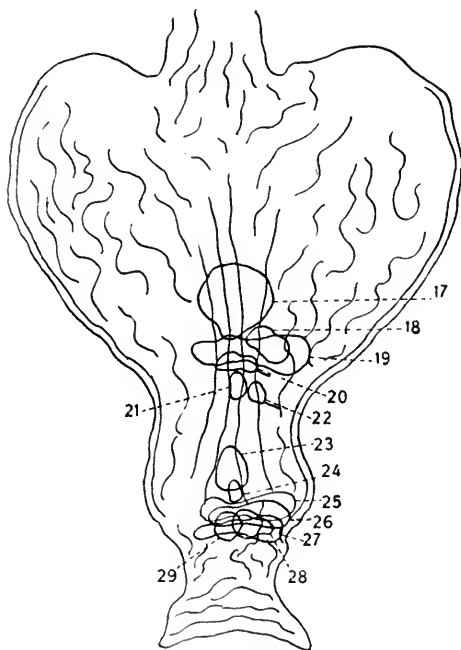


Fig. 3.—Composite illustration of gastric ulcers in eleven cases, showing tendency to grouping at pylorus and at a distance from the pylorus (Shur and Plaschkes, Footnote 6).

CASE 3.—A. H., a section hand, aged 70, had a perforating ulcer at a distance from the pylorus. The Ewald test revealed: total acids, 40; free hydrochloric acid, 25. A Billroth II operation was performed, Oct. 22, 1919. When reexamined Oct. 29, 1920, the Ewald test revealed: total acids, 5; free hydrochloric acid, 0. Fluoroscopic examination disclosed quick emptying. The patient feels well and can work. There is no gastric or abdominal distress. He has gained 20 pounds and is slightly constipated.

CASE 4.—M. B., housewife, aged 62, had an ulcer at a distance from the pylorus and one perforating ulcer on the posterior wall. The Ewald test revealed: total acids, 60; free hydrochloric acid, 35. A Polya operation was performed Sept. 22, 1920. The patient was reexamined Nov. 1, 1920. The Ewald test revealed: total acids, 18; free hydrochloric acid, 0, and a small

amount of bile. Fluoroscopic examination demonstrated that the motor meal began to leave the stomach at once. The patient feels well and is gaining in weight.

CASE 5.—F. H., farmer, aged 63, had a perforating ulcer at a distance from the pylorus on the upper curvature (Figs. 5 and 6). The Ewald test revealed: total acids, 55; free hydrochloric acid, 25. A Billroth II operation was performed March 27, 1920. The patient was reexamined Oct. 30, 1920. The Ewald test revealed: total acids, 7; free hydrochloric acid, 0; lactic acid, 0, and no bile. Fluoroscopic examination demonstrated the motor meal beginning to leave the stomach at once. He feels excellent, has good color, has gained 30 pounds in weight, works on his farm, and the bowel movements are regular.

CASE 6.—O. R., farmer, aged 59, had an ulcer at a distance from the pylorus on the upper curvature. There is no record of the Ewald test. A Billroth II

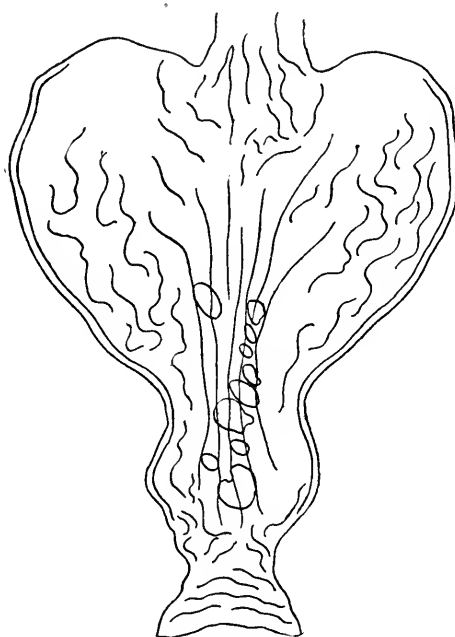


Fig. 4.—Composite illustration of multiple ulcers of stomach in eleven cases (Shur and Plaschkes, Footnote 6).

operation was performed, Sept. 20, 1919. He was reexamined Nov. 4, 1920. The Ewald test revealed: total acids, 35; free hydrochloric acid, 19. Fluoroscopic examination showed the operative record to be faulty as the whole stomach and duodenum were plainly visible. The gastro-enterostomy was not functioning. He feels fairly well but still has some gastric distress. The case is retained in this list to show contrast as to acidity.

CASE 7.—F. K., laborer, aged 61, had a perforating ulcer on the lesser curvature at a distance from the pylorus. There is no record of the Ewald test. A Billroth II operation was performed, June 23, 1919. He was reexamined Oct. 28, 1920. The Ewald test showed the meal removed after one hour and ten minutes; total acids, amount of specimen too small; no free hydrochloric acid. He looks and feels well, has gained 20 pounds in weight and works every day.

CASE 8.—C. L., blacksmith, aged 52, had a perforating ulcer on the lesser curvature at a distance from the pylorus. The Ewald test revealed: total acids, 45; free hydrochloric acid, 20. A Billroth II operation was performed, July 19, 1919. He was reexamined Nov. 5, 1920. The Ewald test revealed: total acids, 9; free acids, 0. He has gained 40 pounds, feels well and rugged, and works at his trade.



Fig. 5.—Perforating ulcer of stomach.

CASE 9.—J. K., a man, aged 48, had an ulcer on the upper curvature at a distance from the pylorus. A Billroth II operation was performed. The Ewald test revealed: total acid, 55; free hydrochloric acid, 0. He feels well, has gained 10 pounds and works on his farm. His color is excellent.



Fig. 6.—Perforating ulcer of stomach.

#### COMMENT

A review of these cases shows that the operations performed were: seven Billroth II, one sleeve resection of the pyloric antrum and one Polya operation. In the study of these nine cases, it is of interest to note that all except one patient (Case 3) have been operated on for more than a year, that is from thirteen to twenty-two months. The one exception (Case 3) is the latest case, and the patient is now ready to leave the hospital, having been operated on six weeks at the time of



the reexamination. All except A. H. (Case 3) have been able to return to their usual work. All have been absolutely free from gastric or abdominal distress since the operation except A. K. (Case 1). All have gained in weight, varying from 5 to 20 pounds. All fluoroscopic examinations were made in a standing position. The barium meal showed the position of the stomach well to the left of the spine. All of these patients were able to take and retain the usual amount of barium meal without difficulty, thus showing the capacity of the stomach to be sufficient. The gas bubble was present as in normal stomachs. The meal began to leave the stomach immediately.

The results of the examination for gastric acidity are: The amounts returned by the stomach tube varied from  $\frac{1}{2}$  ounce to 4 ounces. As these stomachs were emptied by various persons and at somewhat varying intervals, I am not at liberty to draw conclusions as to the length of time food was retained in these stomachs. The acidity, however, shows the interesting fact that all of the patients showed a low amount of total acids, not over 19, *and no free hydrochloric acid whatever*, except in Case 2, in which a sleeve resection was performed, leaving the pylorus and a portion of the antrum. In this case a trace of hydrochloric acid was found. All specimens were free from bile except in Case 4, in which a Polya operation was performed and in Case 2, in which the sleeve resection was performed. The low acidity and achylia had so far led in no case to intestinal disturbances. No cases of diarrhea were recorded, but moderate constipation was noted instead.

A. K. (Case 1), operated on twenty-two months ago, necessitates more minute consideration. The macroscopic diagnosis was excavating ulcer of the pylorus; but this was changed to cancer under the microscope. This patient has had some distress and has reported vomiting on two different occasions. The barium meal showed a slightly larger stomach than the others, and there appeared to be some obstruction from 2 to 3 cm. beyond the stomach, suggesting a kink in the bowel. Whether or not we have to do with a beginning return of the carcinoma, or with a defect in technic (this being the first case) must for the present be left undecided.

It will be observed that the results of our own cases correspond in every particular to those obtained by Schur and Plaschkes, as far as acidity and increased motility are concerned. While all patients were completely satisfied with the result of their operations and had good health, it may, nevertheless, be well to give thought to the fact that the removal of so important a portion of the stomach, and the consequent loss of its function, may after all not be a matter of total indifference. The resulting achylia, the loss of pepsin digestion and the hurried

emptying of the stomach are so contrary to what is normal, that we must ever be on the lookout for disturbances. Reassuring in this direction must be the fact that in eight out of the nine cases, more than one year, and in one nearly two years have elapsed, since the operation, with nothing to show that the patient is not in good health. Achylia is occasionally found in anacidity which may be the cause of mild or severe intestinal disturbances, especially diarrhea. Yet it must not be forgotten that achylia may exist for years without symptoms, and is often detected only by accident. Our own patients universally report the occasional use of a cathartic, but no diarrhea.

In looking over the literature on the subject of pyloric resection in chronic gastric ulcer, it is gratifying to note that there is a tendency toward more radical work in this country as well as in foreign lands. Friedenwald, Baltimore, states: "Gastro-enterostomy should be limited as far as possible to pyloric stenosis due to inoperable malignant disease," and advocates the Finney pyloroplasty and pyloric resection for ulcer.

McDonald writes: "It is not impossible, that with greater experience the treatment of gastric ulcer will become more radical. Pylorectomy, although somewhat higher in mortality, may replace gastro-enterostomy, especially if the pylorus is not obstructed. Brown,<sup>7</sup> of the Sippy Clinic, when asked as to his position on operations for chronic gastric ulcer states: "I am for operation, if the surgeon will always cut out the ulcer," evidently being convinced of the apparent futility of a simple gastro-enterostomy.

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7. In a recent personal communication from Dr. Brown, who is intimately connected with Dr. Sippy, chief of a clinic almost exclusively devoted to the nonsurgical treatment of gastric ulcers, he has expressed the wish to comment further on the statement quoted above, which he grants was made by him at the Ninth Councilor District Meeting, at Wausau, Wis., in the fall of 1920. I herewith quote abstracts from his letter:

"If in a given case it could be ascertained with certainty that a chronic peptic ulcer was excisable and were it not for the high mortality attendant on the attempt to excise chronic ulcer of the stomach and duodenum, excision could, in many cases where conditions for healing are none too favorable, be considered excellent treatment; but in the actual handling of cases it is well recognized that rarely is a surgeon in a position to know before opening the abdomen whether a given ulcer is excisable or not. As you have no doubt often observed, pathologic conditions frequently exist which render removal too hazardous a procedure and as a matter of record only a relatively small percentage of chronic peptic ulcers are actually excised. . . .

"If a patient can have the benefit of the perfect technic of the most competent surgeons, well and good, but if it is assumed that excision of ulcer is the ideal treatment and every ulcer is to be subjected to laparotomy by surgeons here and there, the mortality figures will inevitably mount to a distressingly higher percentage. . . .

"In other words, we firmly believe in the medical treatment for chronic peptic ulcer except in those cases where roentgen ray shows a lesion so broad and deep that it is reasonable to assume that conditions for healing are not favorable. . . ."

Of the Balfour operation, I am not in a position to speak from experience. It consists in thoroughly burning out the ulcer with the electric cautery and then suturing over the edges of the defect. Among other advantages, he reports that little or no distortion of the stomach results. I shall be convinced of this only when a sufficient number of cases have been reexamined and his assertions confirmed. Meanwhile, and in view of what I accept as the cause of ulcers and of what I consider as an absolute requirement for a cure, i.e., an acidity, I shall continue to perform pylorotomies with an open mind as to future results.

## CONCLUSIONS

1. The cure of chronic gastric ulcer by gastro-enterostomy alone is doubtful.
2. Gastro-enterostomy gives the best results in ulcers near the pylorus accompanied by pyloric stenosis.
3. Only temporary benefit can be hoped for after gastro-enterostomy in ulcers which are distant from the pylorus.
4. Pylorotomy with posterior gastro-enterostomy fulfills the principle requirement for the cure of gastric ulcer, i.e., removal of acidity, better than any other operation.
5. It is not necessary to fear or discuss the theoretically harmful effects of a resection of the pylorus until they are reported.<sup>8</sup>

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8. In addition to the references already given, the following will be found of interest:

Gross and Held: Indications for Surgical Treatment in *Ulcera Ventriculi*, Surg., Gynec. & Obst. **27**:567 (Dec.) 1918.

Gundelfinger, Ernst: Klinische und experimentelle Untersuchungen über den Einfluss des Nervensystems bei der Entstehung des runden Magengeschwürs, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **30**:189, 1918.

Troell, A.: Gastric and Duodenal Ulcers from a Surgical Point of View, Ann. Surg. **66**:664 (Dec.) 1917.

Témoin: Gastric Surgery, Bull. Acad. de méd. **78**:737, 1917.

# TRAUMATIC SPONDYLOLISTHESIS

## REPORT OF TWO CASES

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A review of the literature indicates that while dislocations of the fifth lumbar vertebra have been diagnosed and reported, the condition is exceedingly rare.<sup>1</sup> It is only within recent years that the diagnosis suggested by the history and clinical examination can be confirmed by roentgenograms. Even today the peculiar and unusual roentgenographic appearance is not recognized by many. An anteroposterior picture of a forward dislocation of the fifth lumbar vertebra is, however, so striking that when once seen and understood, a second case will not be overlooked.

Roentgenographic definition of the structures in the lumbosacral region is difficult because: (1) The fifth lumbar vertebra has a wide range of normal morphologic variation; (2) the forward inclination of the fifth lumbar vertebra and the sacrum makes it difficult to obtain a clear outline of these bones; (3) overdeveloped transverse processes of either the last lumbar or first sacral segment change or obscure the relation of the fifth lumbar, sacrum and iliac bones, and (4) the proximity and size of the iliac bones interfere with a good lateral view of the fifth lumbar vertebra and especially of the lumbosacral joint. In studying the lumbosacral region, anteroposterior, lateral and oblique views are necessary to obtain the fullest possible information. Stereoscopic roentgenograms are preferable to flat impressions. Dr. Byron C. Darling recently described very clearly the roentgen-ray appearance of the anteroposterior picture of a bilateral forward dislocation of the fifth lumbar vertebra. He reported five cases from the services at the Hospital for Ruptured and Crippled. The appearance was the same in all. In these cases, as in the two about to be described, there was a bilateral forward subluxation of the fifth lumbar vertebra. The dislocation in all but one of the cases in the literature was incomplete. In one instance, an anatomic specimen, there was complete dislocation of the fifth lumbar vertebra, which was found to lie on the anterior surface of the sacrum.

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1. A recent textbook on injuries (Moorehead: Traumatic Surgery, 1917) does not even mention it.

## EVIDENCES OF SPONDYLOLISTHESIS

The cardinal clinical evidences of spondylolisthesis are: (1) prominence of the sacrum; (2) a *hollow*, palpable and frequently visible immediately above the sacrum; (3) pains in the back and lower extremities; (4) weakness and stiffness of the back; (5) lordosis; (6) forward bending of the trunk, and (7) tenderness of the lumbosacral region.

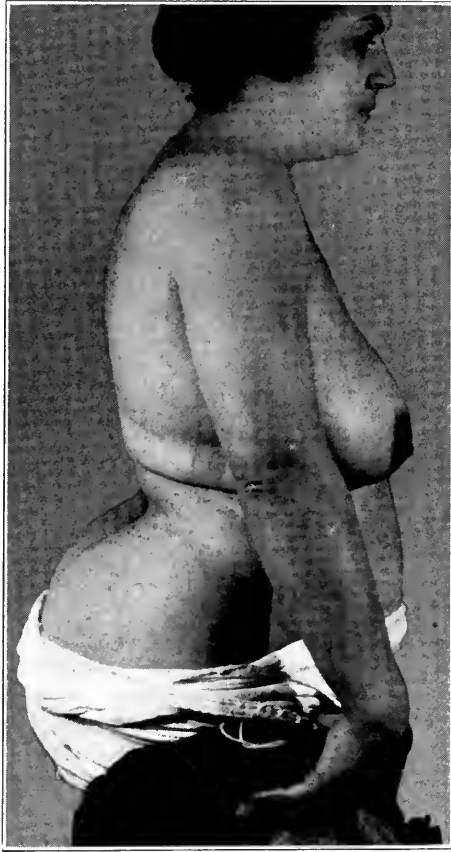


Fig. 1.—Marked lordosis simulating spondylolisthesis.

*Prominent Sacrum.*—In forward dislocation of the fifth lumbar vertebra, all of the lumbar vertebrae are displaced forward and the normal backward projection of the sacrum is exaggerated. Prominence of the sacrum when unaccompanied by any other pathologic changes is not of much importance, as it may be due to postural lordosis, congenital lordosis, or hypertrophy of the sacral spinous process. It is

of very great importance when associated with the condition which is discussed next.

*A Hollow or Depression in the Lower Lumbar Region.*—Normally, the spinous processes of the fourth and fifth lumbar and the first sacral vertebrae are practically in the same coronal plane, and the hand



Fig. 2 (Case 1).—Anteroposterior view of lumbar vertebrae and sacrum. Shadow of fifth lumbar vertebra is in front of upper part of sacrum. Outline of upper surface of fifth lumbar vertebra including body, lateral masses, spinous process and spinal foramen may be noted. Outline of other lumbar vertebrae is rectangular. The superior surface of the fifth lumbar vertebra is seen because it has slipped downward and forward.

passing upward over the sacrum comes into immediate contact with the lumbar spinous processes. The lumbar and sacral spines form a *continuous line*. In forward dislocation of the fifth lumbar vertebra, there is an appreciable interval between the first sacral spinous process and that of the fifth lumbar vertebra. The latter is found in a hollow in front of its usual position, and the examining fingers enter a space immediately above the sacrum. A hollow above the sacrum is the most suggestive sign of spondylolisthesis. It is not always reliable, however, as is demonstrated by the accompanying illustration (Fig. 1) of a middle aged woman who presented a prominent sacrum and a hollow above it. This patient complained of weakness of her back, and clinically spondylolisthesis seemed the most likely diagnosis. Roentgen-ray examination showed, however, that there was no slipping of any of the lumbar vertebrae, the case being one of congenitally abnormal lordosis.

*Pain in the Back and Lower Extremities.*—Pain in the back occurs frequently. It is usually definitely limited to the lumbosacral region and is a persistent symptom though it varies greatly in intensity. In some patients, it may not amount to more than an annoying ache, while in others, as in one of my patients, it is distressing and disabling. Frequently, too, there is pain of a variable degree in one or both lower limbs, accompanied by muscular weakness which results in partial paralysis and interference with locomotion. The pain and motor weakness are the result of pressure of the displaced vertebra on the lumbar and sacral plexus nerves. Considering the tearing and other injury that the nerve-laden soft parts about the displaced vertebra undergo, it is remarkable that there sometimes is so little discomfort.

*Weakness and Stiffness of the Back.*—It is only natural that the lumbar spine is limited in mobility. The restriction of motion is due to both the dislocation of the vertebra and the injury of the soft parts. Flexion of the spine is restricted the most; lateral bending is restricted to a less degree, and extension and hyperextension are limited very little or not at all. In fact, the individual may develop hyperextension of the lumbar spine or lordosis as a compensatory measure to maintain the body in an erect position. Not only is the back limited in its mobility, but it is also weak. The weakness varies in degree; but it is always present, and to the patient it is one of the most important symptoms. Usually the weakness is not extreme and causes only partial disability, permitting light work.

*Lordosis.*—In cases of long standing and in instances in which the pain is not very severe, the patient has accommodated himself to the forward slipping of the lumbar vertebra by assuming an overerect attitude. Thus there is established a continuous exaggeration of the

normal forward curve of the lumbar spine, or lordosis. The lordosis increases the abnormal prominence of the sacrum.

*Forward Bending of the Trunk.*—This has been noticed very frequently. The body is inclined forward and to one side. This symptom is inconstant; it may be present one day and not another. It is not at all confined to spondylolisthesis, as it is found in sprains of the back, fracture of the spine, sacro-iliac relaxation or sprain, spondy-

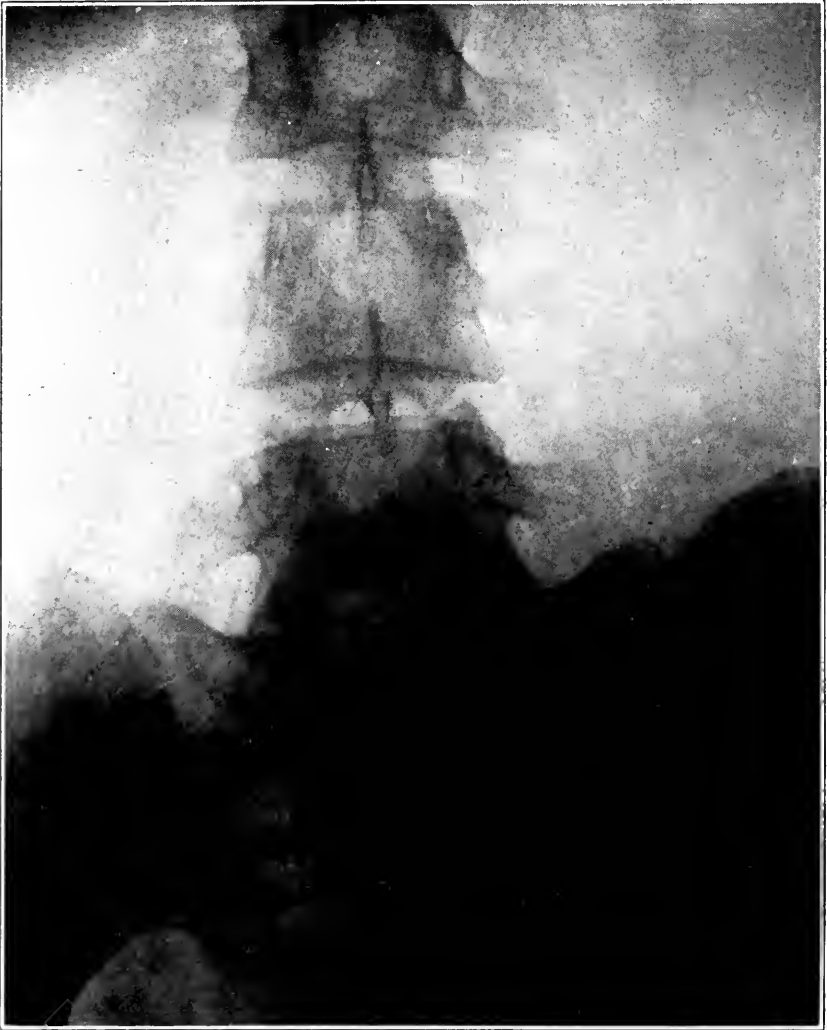


Fig. 3.—Normal fifth lumbar vertebra. Rectangular outline may be noted and the spinous process may be seen in the middle of the shadow of the vertebral body. Pedicles, laminae and spinal foramen are not seen. There is a distinct interval between the fifth lumbar vertebra and the sacrum.



litis, sciatic scoliosis and other conditions of inflammation in, or injury to or about, the spine. It is an attitude which the patient assumes in an attempt to relieve himself of pain.

*Tenderness of the Lumbosacral Region.*—There is usually definitely limited tenderness at the site of dislocation. Its intensity varies with the duration of the lesion. It is most marked during the months immediately following the dislocation and very slight in cases of long standing.

#### COMMENT

Of the symptoms just described, an abnormally prominent sacrum and a hollow above the sacrum are the only ones that are suggestive

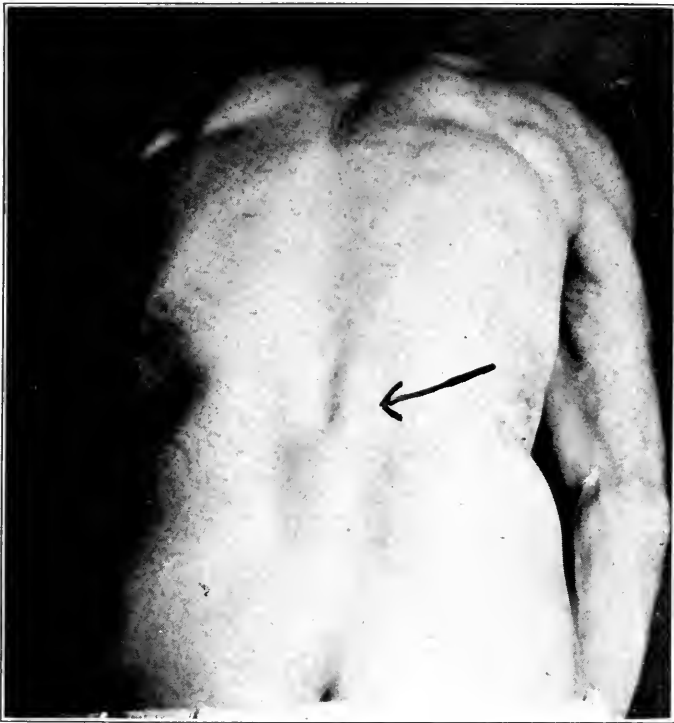


Fig 4 (Case 2).—Prominence of upper part of sacrum and hollow above it.

per se of spondylolisthesis. The others indicate only some sort of lesion in the lower part of the back. The combination of these symptoms, especially if they follow a distinct trauma, strongly suggests a dislocation of the fifth lumbar vertebra, but roentgenograms are required to demonstrate the lesion. In only one recorded case could the diagnosis be made with certainty from the clinical history and examination. This was a case reported by Dr. Ryerson of Chicago.

His patient, a girl, aged about 15 years, had repeated attacks of partial or complete paralysis of the lower limbs. The weakness of the limbs would follow a conscious slipping of the fifth lumbar vertebra. On one occasion, Dr. Ryerson could actually feel the forward slipping of the spinous process. The characteristic roentgen-ray appearance will be described in the report of the cases.



Fig. 5 (Case 2).—Anteroposterior view. Curved outline of body, pedicles, laminae, spinous process and spinal foramen of the fifth lumbar vertebra may be noted. Other vertebrae are represented by rectangular outline of body only. Fifth lumbar is in front of upper part of sacrum.

CASE 1.—E. B., a laborer, aged 55, was sent to me because of persistent pain in his back, and difficulty in walking. He had a compensable injury; and in view of the fact that roentgenograms of his spine were reported to be negative, and as no positive clinical diagnosis had been made, the insurance company was ready to consider him a malingerer.

*History.*—On Sept. 19, 1919, a beam struck him on the back of the neck and threw him to the ground. He was unconscious for a few moments, and when

he regained consciousness, he experienced severe pain in the neck. The neck was bandaged and he was taken home. Later in the same day, he developed severe pain in the lower part of the back. The pain in the neck disappeared within a few days, but the pain in the back remained and has become more

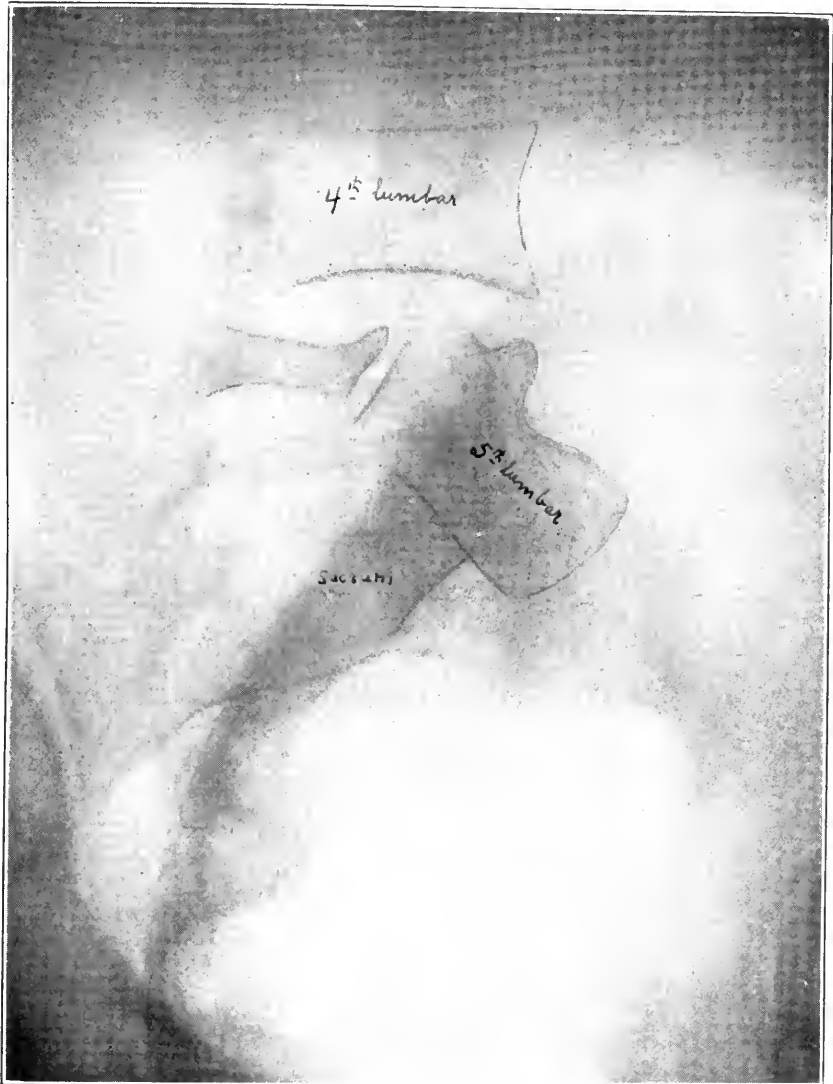


Fig. 6 (Case 2).—Lateral view showing irregular outline of body of fifth lumbar in front of upper part of sacrum.

marked. For eight weeks, he had to remain in bed because of backache. His lower limbs felt stiff, but they were not paralyzed. He did not have then, nor had he since had, any bladder or rectal disturbances. After eight weeks, he was able to get out of bed and walk, but walking had become increasingly more

difficult, so that at present he had to support his hands on his thighs while walking, or when he rose from a chair. His chief complaint was pain in the lower part of the back and weakness of the lower limbs.

*Examination.*—He was in fair general condition. He undressed without assistance but with great effort. The muscles of the back and abdomen were very rigid, and the muscle spasm was evidently for the protection of a painful back. He walked without assistance but very awkwardly and he held the trunk bent forward. He was unable to stand erect. He pointed to the lumbosacral region of the back as the site of his worst pain. His back was symmetrical and the spine was in the median line. There was an obliteration of the normal lumbar lordosis which was replaced by flatness. There was no apparent break in the anteroposterior contour of the spine. The motions of the spine were

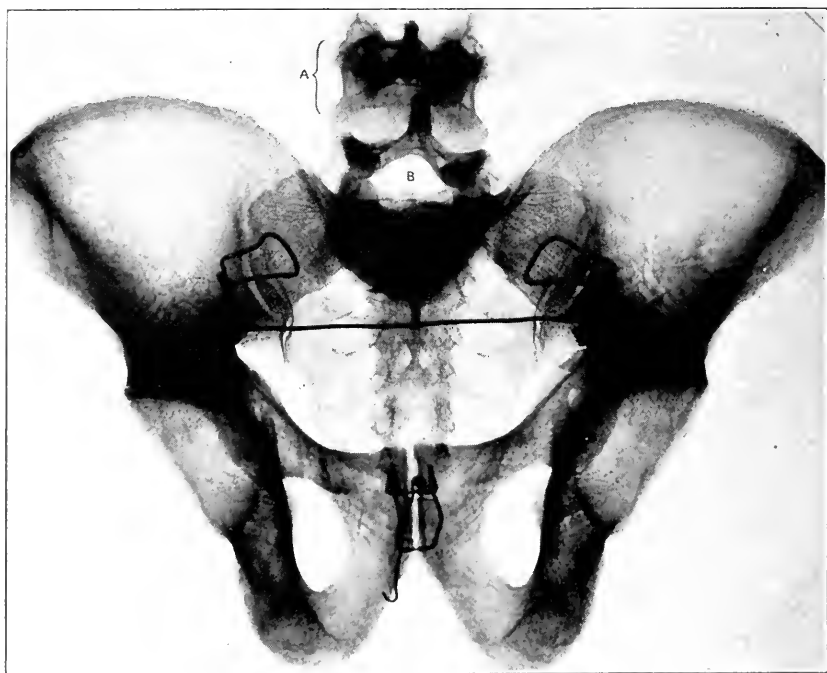


Fig. 7.—Anteroposterior view of a subluxated fifth lumbar vertebra: *A* indicates fourth lumbar vertebra and *B*, the spinal foramen of the fifth lumbar. The outline of the superior surface of this vertebra overlies the upper part of the sacrum. The fourth lumbar is rectangular.

very markedly restricted and painful. Flexion of the spine was limited to only a few degrees. Extension and hyperextension were entirely restricted. Lateral bending in either direction was very markedly restricted. Palpation revealed exquisite tenderness of the spinous processes of the fourth and fifth lumbar vertebrae. Pressure of a moderate degree in this region caused the patient to fall to the floor. There was no tenderness of any other part of the spine. Palpation further revealed that there was a sunken region or hollow immediately above the sacrum, between the sacrum and the fourth lumbar spinous process. Accurate palpation of the fifth lumbar spinous process was not possible because

of the extreme tenderness; but it was evident from the existence of the hollow above the sacrum that the fifth lumbar spinous process was displaced forward and was anterior to its normal position. Both sacro-iliac joints appeared normal and were not tender. Tapping the patient on the head very lightly caused pain in the lumbosacral region. Both knee jerks and ankle reflexes were present and equal. He was able to raise both lower limbs, demonstrating that there was no paralysis of either. He raised the lower limbs with great effort and not very



Fig. 8.—Lateral view of subluxated fifth lumbar vertebra: *A* indicates sacrum; *B*, fourth lumbar vertebra and *C*, fifth lumbar. The irregular outline of the body of this vertebra is in front of the sacrum.

freely, indicating that there was muscle weakness, or that this motion initiated and was inhibited by pain in the back.

Roentgen-ray examination of the entire back from the first cervical to, and including, the coccyx revealed no abnormality except at the lumbosacral junction. Here in an anteroposterior view, we noted these findings: Figure 2 presents an outline of the upper surface of the fifth lumbar vertebra, namely,

the curved upper surface of the body which lies over the upper part of the sacrum, the pedicles, transverse processes, laminae, spinous process and spinal foramen of the fifth lumbar vertebra. In other words, in an anteroposterior view, in which normally (Fig. 3) we can see only the rectangular outline of the body of the fifth lumbar vertebra and a shadow of the spinous process at about its middle, we see in this case the entire outline of the upper surface of the fifth lumbar vertebra, as if we were looking down upon it from above. Such an appearance can mean only one thing, namely, that the fifth lumbar vertebra has become tilted downward and forward so that its superior surface faces forward and inasmuch as the body of the fifth lumbar vertebra lies over the upper part of the body of the sacrum, the roentgen-ray appearance indicates a bilateral forward subluxation of the fifth lumbar vertebra upon the sacrum. The anterior border of the upper surface of the fifth lumbar vertebra forms a curve with the convexity downward lying over the junction of the second and third sacral segments. The picture of the superior surface of the fifth lumbar vertebra is in marked contrast to the appearances of the bodies of the other lumbar vertebrae which are rectangular in outline and of the usual normal appearance. The contrast between the appearance of the fifth and the other lumbar vertebrae is very marked and, to my mind, pathognomonic. Clinically, the hollow above the sacrum and the abnormally anterior position of the fifth lumbar spinous process accord with the roentgen-ray findings.

#### COMMENT

The injury in this case was evidently the result of a forced flexion of the spine, resulting in rupture of the lumbosacral ligaments and forward subluxation of the fifth lumbar vertebra. It cannot be denied that the subluxation was made possible by the presence of the mal-developed first sacral segment, but we have no proof of the existence of such a congenital malformation, at least not in this case. It is interesting further to note that although the disability in this instance, as in the majority of similar conditions, may be severe, it is rarely so marked that the patient cannot walk. This patient, also presented a forward stooping of the body, which is considered by some to be characteristic of spondylolisthesis, but which in our experience occurs only inconstantly.

The important features in this case are: First, the clinical examination indicated a lesion in the lumbosacral region, but this was not at all characteristic of spondylolisthesis. Second, the roentgenograms are typical and indicate beyond any doubt the presence of a dislocation of the fifth lumbar vertebra. Third, roentgenograms, which had been taken soon after the injury, and which show the lesion, were said to be negative, that is, the peculiar and pathognomonic roentgen-ray appearance was not recognized and a diagnosis of the condition was not made. Fourth, this patient was examined by ten different physicians during a period of fourteen months without having the condition diagnosed. This is due to two facts: first, that the examining physicians did not realize that clinically the man presented evidences, by the

presence of localized pain and tenderness and limited motion at the lumbosacral junction, that there was a lesion in this part of the back, and second, as previously noted, the roentgen-ray appearance was not properly interpreted.

CASE 2.—F. M., a man, aged 35 years, was sent to me because of persistent pain in the lower part of the back and pain and weakness of the left lower limb. This man presented an appearance of the back which clinically is the most suggestive of spondylolisthesis, namely, a condition of prominence of the sacrum and a hollow above the sacrum.

*History.*—This patient while carrying a weight on his right shoulder on July 6, 1920, had another weight thrown onto his shoulder when he did not expect it. This caused him suddenly to "cave in" as he expressed it. He felt a severe pain in the back at the time; but did not fall to the ground. He caught himself just as he got to the ground and straightened up. The pain in the back continued to annoy him; but he was able to work until the end of the day, which was two hours after his injury. He then consulted a physician who told him he had a sprain of the back. Three months after his injury, the pain in the back had become so severe that he had to give up all kinds of work. It is of interest to note that this patient became aware of the hollow in the lower part of the back soon after the injury.

*Examination.*—He was in good condition. He walked without assistance but with a limp on the left side. He stated that he was conscious of dragging the left leg. He held his body erect.

*Back:* There was a very distinct hollow in the middle of the back immediately above the sacrum on a level with the crests of the iliac bones (Fig. 4). The top of the sacrum was very prominent. The hollow in the lumbosacral region was exaggerated when the patient bent forward. There was marked increase in the normal lordosis of the lumbar region. Palpation of the spine revealed that the fourth and fifth lumbar spinous processes were in the hollow above the sacrum and in a position anterior to their normal places. Flexion of the spine was markedly limited. Extension, hyperextension and lateral bending in either direction were unrestricted, but moderately painful. Forced flexion of the body caused pain along the left sciatic nerve. There was moderate tenderness of the lower lumbar spinous processes. This was in marked contrast to the exquisite tenderness of this region that our first patient presented. Examination of the left lower limb showed that there was moderate atrophy of the thigh and definite weakness of all of the muscles of the thigh and leg.

The diagnosis of spondylolisthesis, made at this juncture, was based upon the presence of the hollow in the lower lumbar region and upon the abnormal prominence of the sacrum.

Roentgen-ray examination in this case, as in the preceding one, shows in the anteroposterior view (Fig. 5) of the lumbosacral region that the body of the fifth lumbar vertebra was subluxated forward. In this view, in which we normally see a rectangular outline of the fifth lumbar vertebra, that is the outline of the anterior surface of the body, we are actually looking down upon the superior surface, for we are able to distinguish the upper surface of the body, the spinal foramen, the pedicles, the laminae and the spinous process of this vertebra. In the lateral view (Fig. 6) the body of the fifth lumbar vertebra is seen to be very irregular and subluxated forward. There has, therefore, been a crushing of the body of this vertebra in addition to a subluxation. The lateral

masses of the fifth lumbar vertebra appear irregular and are very much larger than normal, so that it is likely that they were fractured and that there is separation of the anterior from the posterior portions of the vertebra.

The interesting points in this case are:

1. The patient presented typical signs of spondylolisthesis.
2. The roentgenograms show the peculiar and characteristic appearance.
3. The patient was able to continue at laborious work for several months after his injury.
4. He had only moderate discomfort in his back. Most of the pain was in the left lower limb and was the result of pressure of the dislocated vertebra upon the lumbar and sacral nerves.

#### COMMENT

My diagnosis in this case was doubted because the patient was able to continue his work for some time after the injury. It should be recalled that in most of the recorded cases of spondylolisthesis the patients were able to walk about and attend to some part of their duties. Theoretically it would appear that the disability should be extreme. Experience, however, proves that it is not so. In this case, the man stated that he could go back to work now if it were not for the pain and weakness of the left leg. In his mind, the back was of secondary importance. At least two of the five patients whose cases Dr. Darling reported, and whom I had an opportunity of examining, had only slight disability. I remember being surprised at the comparatively slight inconvenience caused by the dislocation. This fact is of some importance in cases of compensatable injuries in which the ability of the claimant and patient to do some work may be misinterpreted.

As previously mentioned, the roentgen-ray appearance of the fifth lumbar vertebra in spondylolisthesis is peculiar and pathognomonic. I have not seen the sort of roentgenogram above described in any condition other than spondylolisthesis, nor have I seen or heard it mentioned as pertaining to any other condition. At a recent clinical conference where I presented the roentgenograms of the first case, it was suggested that a forward tilt of the sacrum might produce the same appearance. However, in such cases the roentgenograms do not give the appearance of spondylolisthesis. As a further link in the proof that the roentgenographic markings considered diagnostic of spondylolisthesis are pathognomonic, I took a pelvis and the fourth and fifth lumbar vertebrae and produced a bilateral forward subluxation of the fifth lumbar vertebra. The accompanying roentgenograms taken in the anteroposterior and lateral planes show exactly the same findings as are described in the cases here reported. We see in the anteroposterior plate (Fig. 7) the crescentic outline of the body and pedicles of the fifth lumbar vertebra, its laminae, spinous process and spinal foramen. We are looking down on the superior surface of the fifth



lumbar vertebra. The body of the fourth is rectangular in outline. The lateral view (Fig. 8) is especially interesting as it shows very clearly the shadow of the body of the fifth lumbar vertebra in front of the sacrum. In the living subject, this shadow is very indistinct and often overlooked; when seen it is frequently improperly interpreted. These pictures are, I believe, convincing, and indicate that the roentgenographic appearance heretofore described is characteristic and diagnostic of spondylolisthesis.

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# STUDIES IN EXHAUSTION

## II. EXERTION

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Every vital process demands muscular activity. No voluntary act can be performed without muscular participation. Exertion is the most constantly present of all the phenomena of conscious life, and extreme exertion, therefore, is the most normal manifestation of intensified consciousness.

In studies of exertion, however, as in all studies of bodily activation, it is obviously impossible to isolate the effects of exertion from those caused by certain other coincident factors. All that we can do is to make sure in each case that exertion is the dominant factor. For example, a fox chased by hounds is activated by fear, by the exertion of running, by anger and fear during the fight preceding death, and, finally by the trauma of the death struggle. Any one of these factors alone might cause marked injury to the organism; but the dominant activation seems to be physical exertion. Moreover, the emotions are in abeyance during free exertion. It is for this reason that the data on chased foxes are included in a discussion of exertion rather than of emotion. For the same reason, we may consider that exertion plays the major part in the activities of a fighting dog, of a swimming rat, or of a salmon swimming up stream to the spawning ground in the headwaters of a river.

Since there is evidence that the action current which passes over a nerve is electric energy, we include in this section also observations on electric fish and on the results of the electric stimulation of dogs.<sup>1</sup>

### A. HISTOLOGIC STUDIES

#### COMBINED EXERTION AND FEAR IN RED FOXES

A neighboring hunt club offered the opportunity to obtain two foxes which had been chased by hounds for different periods of time.

EXPERIMENT 1.—A vixen was caught and killed after a run of about a mile over snow. The animal did not appear to be completely exhausted. The brain was removed within twenty minutes after death. The results of a differential count of 100 Purkinje cells are given in Table 2.

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1. The author wishes to express his appreciation of his indebtedness to his collaborators in these investigations, especially to Dr. J. B. Austin and F. W. Hitchings for the histologic studies, and to Dr. M. L. Menten, Dr. B. J. Harrison, Dr. W. B. Rogers, Dr. R. E. Mosiman, and Miss Amy F. Rowland, and Dr. Houghton and his associates at the Parke, Davis laboratories, for valuable assistance in various phases of the research.

TABLE 1.—DIFFERENTIAL PURKINJE CELL COUNTS FROM TWO NORMAL FOXES

Stage	Active		Fatigued				Exhausted			
	I	II	III	IV	V	VI	VII	VIII	IX	X
Normal fox 1.....	41	31	14	6	6	2	0	0	0	0
Grouped.....	72%		28%				0%			
Normal fox 2.....	40	30	18	6	3	2	0	1	0	0
Grouped.....	70%		29%				1%			
Group average.....	71%		28.5%				0.5%			

TABLE 2.—DIFFERENTIAL PURKINJE CELL COUNTS FROM A NORMAL FOX AND FROM A FOX CHASED ONE MILE

	Active, per Cent.	Fatigued, per Cent.	Exhausted, per Cent.
Chased fox.....	85	12	3
Normal fox (average).....	71	28.5	0.5

%	10	20	30	40	50	60	70	80	90
<u>Active</u>	1-mile chase								
	7-mile chase.								
	Normal Fox								
<u>Fatigued</u>	1-mile Chase.								
	7-mile Chase.								
	Normal Fox.								
<u>Exhausted</u>	1-mile Chase.								
	7-mile Chase.								
	Normal Fox.								

Fig. 1.—Differential Purkinje cell count, showing the comparative effects of brief and of prolonged exertion on the brain cells of foxes. The increase in the number of active cells after short exertion may be compared with the hyperchromatic cells after brief exertion in a dog (Fig. 2, B).

This comparison shows that, as a result of the chase, the number of hyperchromatic cells had been increased practically 14 per cent., while the number of exhausted cells had increased only 2.5 per cent. Compare these percentages with those in the following experiment in which the fox had been chased seven miles before it was caught.

EXPERIMENT 2.—A vixen was caught by the hounds after a run of seven miles. The brain was removed a little more than two hours after death.

A differential count of 100 Purkinje cells yielded the results given in Table 3.

TABLE 3.—DIFFERENTIAL PURKINJE CELL COUNTS FROM A NORMAL FOX  
AND FROM A FOX CHASED SEVEN MILES

	Active, per Cent.	Fatigued, per Cent.	Exhausted, per Cent.
Chased fox.....	41	50	9
Normal fox (average).....	71	28.5	0.5

The almost entire absence of hyperchromatic cells, and the largely increased number of exhausted cells in this experiment when compared with the larger number of hyperchromatic cells in Experiment 1 indi-

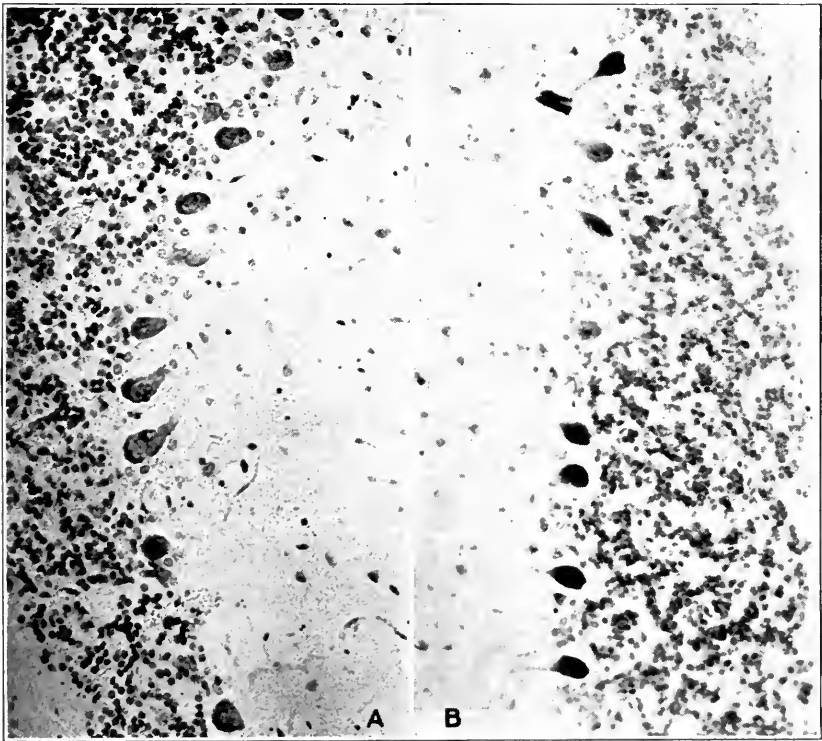


Fig. 2.—Effect of brief violent exertion combined with anger on the brain cells of a dog, from photomicrographs  $\times 310$ : *A*, section of normal cerebellum of a dog immediately after a light. The hyperchromatic condition of the cerebellum and the disorganized state of all the Purkinje cells in *B*, as compared with the Purkinje cells in *A*, may be noted.

cate, as do similar results in other experiments, that the first effect of the activation of an animal is an increase in the Nissl staining material, which we have reason to believe is associated with the power of energy transformation (Fig. 1 and Table 4).

TABLE 4.—SUMMARY OF DIFFERENTIAL PURKINJE CELL COUNTS IN NORMAL AND IN CHASED FOXES

	Active, per Cent.	Fatigued, per Cent.	Exhausted, per Cent.
Normal fox 1.....	72	28	0
Normal fox 2.....	70	29	1
Chased fox 1 (1 mile).....	85	12	3
Chased fox 2 (7 miles).....	41	50	9

## COMBINED EXERTION AND ANGER IN DOGS

The dogs from which normal histologic studies were made were normal mongrels, which were kept under identical conditions as regards

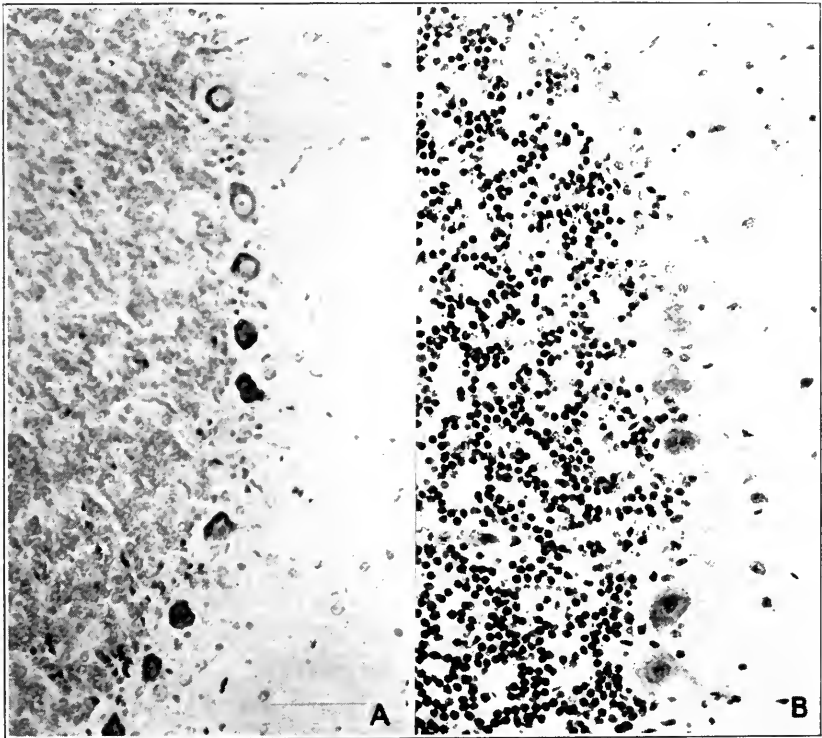


Fig. 3.—Effect of continuous exertion on the brain cells of a cat, from photomicrographs  $\times 310$ : *A*, section of normal cerebellum of a cat, *B*, section of cerebellum of a cat after continuous exertion for four hours.

food, light and air. Before being used, each was carefully inspected for signs of abnormality or of disease. They were killed by stabbing. The differential Purkinje cell counts are given in Table 5.

TABLE 5.—DIFFERENTIAL PURKINJE CELL COUNTS FROM TEN NORMAL DOGS

Stage	Active		Fatigued				Exhausted			
	I	II	III	IV	V	VI	VII	VIII	IX	X
Normal dog 1.....	37	32	14	9	6	1	0	1	0	0
Grouped.....	69%		30%				1%			
Normal dog 2.....	35	35	14	8	4	3	0	1	0	0
Grouped.....	70%		29%				1%			
Normal dog 3.....	54	25	14	6	1	0	0	0	0	0
Grouped.....	79%		21%				0%			
Normal dog 4.....	39	36	10	8	4	1	0	2	0	0
Grouped.....	75%		23%				2%			
Normal dog 5.....	43	27	19	8	3	0	0	0	0	0
Grouped.....	70%		30%				0%			
Normal dog 6.....	41	25	20	7	5	2	0	0	0	0
Grouped.....	66%		34%				0%			
Normal dog 7.....	50	19	21	5	3	1	0	1	0	0
Grouped.....	69%		30%				1%			
Normal dog 8.....	48	32	11	6	2	1	0	0	0	0
Grouped.....	80%		20%				0%			
Normal dog 9.....	39	32	16	9	3	1	0	0	0	0
Grouped.....	71%		29%				0%			
Normal dog 10.....	36	27	19	9	5	2	0	2	0	0
Grouped.....	63%		35%				2%			
Group average.....	71.2%		28.1%				0.7%			

Occasional dog fights in the kennels furnished material for observation of the effects of violent muscular exertion of short duration plus intense anger and some physical injury. In the case cited here, the defeated dog was killed at once and his brain removed immediately.

As shown in Table 6 there was a marked decrease in the number of active cells and increase in the number of fatigued and exhausted cells (Fig. 2).

TABLE 6.—DIFFERENTIAL PURKINJE CELL COUNTS IN NORMAL DOGS AND IN A DOG AFTER MUSCULAR EXERTION

	Active, per Cent.	Fatigued, per Cent.	Exhausted, per Cent.
Dog after fight.....	50	47	3
Normal dog (average).....	71.2	28.1	0.7

#### COMBINED EXERTION AND ANGER IN CATS

Nine normal cats were subjected to severe and continuous exertion for prolonged periods, after which four were killed immediately; three were allowed periods of rest; one was subjected to ether anesthesia for two hours; and one was given nitrous-oxid-oxygen for one hour followed by an infusion of sodium bicarbonate.

The histologic lesions in the brain, the suprarenals and the liver are shown in Table 7 and in Figures 3, 4 and 5.

TABLE 7.—HISTOLOGIC CHANGES IN CATS PRODUCED BY EXERTION

Animal	Duration of Exertion	Cerebellum	Cerebrum	Suprarenal	Liver
Female cat; Weight, 2,750 gm.	4 hours	Almost all hyperchromatic; only an occasional cell fatigued	Many hyperchromatic cells; majority of cells fatigued	Cortex: outer one half badly exhausted; cells large, vacuolated with eccentric nuclei Medulla: pale with marked loss of cytoplasm of cells	
Female cat; Weight, 792 gm.	4 hours	Occasional hyperchromatic cells; nearly all fatigued; few exhausted	Occasional hyperchromatic cells; nearly all fatigued; few exhausted	Cortex: almost entirely exhausted; cells large and contain many vacuoles; nuclei well stained Medulla: deeply stained with no loss of cytoplasm	Very slight uniform loss of cytoplasm; granules and nuclei well stained; no vacuolation; cell outlines distinct and nuclei central
Male cat; Weight, 2,198 gm.	4 hours	Few hyperchromatic and active cells; nearly all fatigued; occasional exhausted cell	Occasional hyperchromatic cell; nearly all fatigued; occasional exhausted cell	Cortex: slight loss of cytoplasm in some cells; nearly all normal Medulla: pale; loss of cytoplasm in some cells	
Male cat; Weight, 3,029 gm.	5 hours	Many hyperchromatic cells; most all active; some exhausted; occasional fatigued cell	Most all cells hyperchromatic and active	Cortex: complete loss of cytoplasm and extreme vacuolation in cells of outer half Medulla: pale with marked loss of cytoplasm	Very slight loss of cytoplasm; small vacuoles in some cells
Female cat; Weight, 2,972 gm.	4 hours followed by rest 2 hours	Hyperchromatic and active cells; about equal in number; some cells fatigued and some exhausted	Occasional hyperchromatic cell; many active and many fatigued cells some exhausted cells	Cortex: marked loss of cytoplasm and slight vacuolation in outer one half Medulla: normal	Marked loss of cytoplasm in all cells; most marked around central vein
Male cat; Weight, 3,015 gm.	4 hours followed by rest 2 hours	Most all cells hyperchromatic	Most all cells hyperchromatic and active; only an occasional fatigued cell	Cortex: marked loss of cytoplasm and swelling of cells in outer one third of cortex	No loss of cytoplasm or vacuolation
Male cat; Weight, 4,500 gm.	7 hours killed following day	Most all cells hyperchromatic and active; occasional fatigued cell	Some hyperchromatic cells; most all active; some fatigued cells	Cortex: marked loss of cytoplasm in cells of outer one third Medulla: deeply stained; no loss of cytoplasm	All cells normal; no loss of cytoplasm or vacuolation
Male cat; Weight, 3,500 gm.	5 hours followed by 2 hours ether anesthesia	Occasional hyperchromatic cell; many active and many fatigued cells; some exhausted	Few hyperchromatic and few active cells; most all fatigued; some exhausted	Cortex: almost total loss of cytoplasm and extensive vacuolation in outer two thirds Medulla: pale with marked loss of cytoplasm	Slight loss of cytoplasm in a few cells; most all normal
Male cat; Weight, 4,165 gm.	4 hours followed by NaO for 1 hour then by infusion of sodium bicarbonate; killed an hour later	Well stained; many hyperchromatic and active cells; some fatigued	Occasional hyperchromatic cell; some active cells; most all cells badly fatigued; some exhausted	Cortex and medulla: normal; no loss of cytoplasm	Well stained; normal; no loss of cytoplasm

## PROLONGED EXERTION IN RATS

Rats were placed in a large tank of luke-warm water. The sides of the tanks were smooth and straight so that the rats were forced to swim continuously.

As indicated in Table 8, in some instances the rats were killed immediately after one prolonged period of continuous swimming; in others the periods of swimming were interrupted by periods of rest. The table shows the resultant histologic lesions.

TABLE 8.—HISTOLOGIC CHANGES IN RATS PRODUCED BY CONTINUOUS EXERTION

Animal	Duration of Exertion	Cerebellum	Cerebrum	Spinal Cord	Suprarenal	Liver
Large white rat	25 hours continuous	Few hyperchromatic or active cells most all fatigued and some exhausted	Occasional hyperchromatic cells; some active cells; many fatigued	Cells of anterior motor horn markedly fatigued	Cortex: loss of cytoplasm in outer half; some vacuolated cells Medulla: normal	General loss of granular appearance of cytoplasm, nuclei increased in size
Large white male rat	36 hours continuous	Occasional hyperchromatic cell; most all fatigued; few exhausted	Occasional hyperchromatic cell; many active and some fatigued	Cells of anterior motor horn beautifully stained; no loss of cytoplasm	Cortex: marked loss of cytoplasm and vacuolation in outer half Medulla: pale stain but no loss of cytoplasm	Loss of cytoplasm marked; much vacuolation throughout
White male rat	7 continuous hours on each of 2 consecutive days, one hour on third day	All cells badly fatigued	.....	Cell of anterior motor horn hyperchromatic	Cortex: loss of cytoplasm and vacuolation in outer one half	Moderate loss of cytoplasm throughout
White male rat	36 continuous hours; rest one night; 8 hours exertion in each of 5 consecutive days; 3 hours on 6th day	Some hyperchromatic and many active and many fatigued cells; occasional exhausted cell	Large pyramidal cells hyperchromatic; smaller cells fatigued	Large motor cells hyperchromatic	Cortex: slight loss of cytoplasm and vacuolation in outer one third	Normal

## PROLONGED EXERTION IN SALMON

In researches into vital processes, it is desirable to utilize as far as possible phenomena as they occur in nature. Chased foxes and fighting dogs offered examples of the transformation of energy in natural processes; and Nature's laboratory provided us with another natural experiment in which muscular exertion was more completely isolated from other factors—the migration of salmon for more than 700 miles from the mouth of the Columbia River to the spawning ground at its headwaters.

Through the courtesy of Dr. R. C. Coffey of Portland, Ore., students in the biological laboratories of the University of California secured twelve fresh specimens of salmon, six males and six females, from the mouth of the Columbia River and also six males and six



females from the headwaters of the river. These were killed at once and the required specimens taken and sent to my laboratory for histologic study by Dr. Austin.

At the mouth of the river, the salmon, fresh from their long sojourn in the ocean, are plump, smooth and virile. At the headwaters, after speeding, without food, upstream for more than 700 miles, they are thin and rough in appearance and obviously exhausted. Indeed, the exhaustion is so great that it is said that the fish are often scarcely able to reach their goal, where they spawn and die.

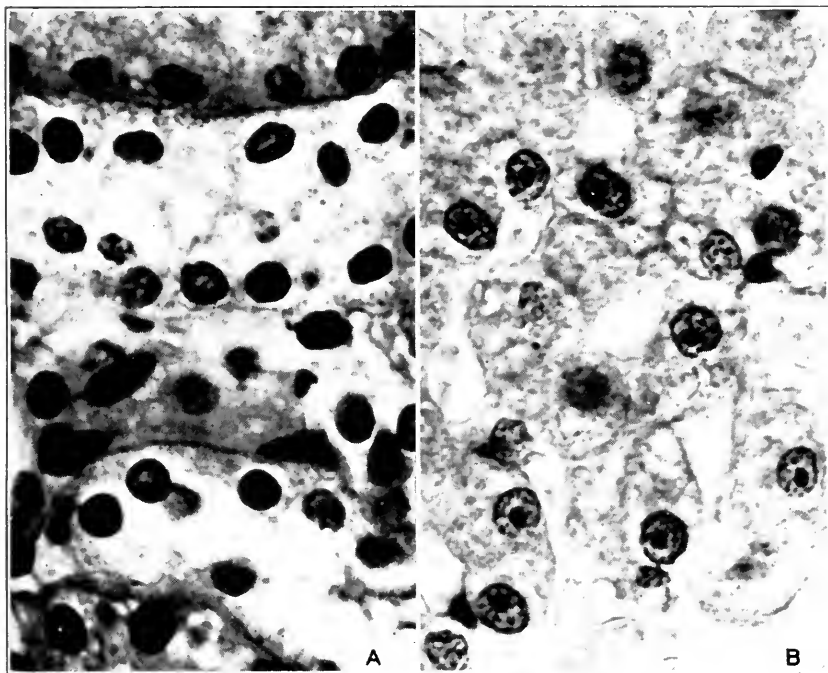


Fig. 4.—Effect of continuous exertion on the liver of a cat, from photomicrographs  $\times 1640$ : *A*, section of normal liver of a cat; *B*, section of liver of a cat after continuous exertion for four hours.

Although they are cold-blooded animals, far removed from the conditions of terrestrial life, yet these fish gave us striking studies of the phenomena of exhaustion from exertion, uncomplicated by other factors. As is shown by the photomicrographs (Figs. 6, 7 and 8) the brain, the liver and the suprarenals show changes identical in character with those caused by insomnia, exertion, emotion, infection, physical injury, etc.; and of even greater significance, these lesions are also identical with those found in the fish whose swimming muscles have become modified into electric batteries.

DISCHARGE OF ELECTRIC MECHANISM IN ELECTRIC FISH  
(*NARCEINE BRASILIENSIS*)

In the electric fish, the powerful swimming muscles, by means of which other fish pursue and escape, are converted into electric batteries, in which are stored charges of electricity. In order that correlative histologic and other studies might be made of this mechanism, an expedition to Cape Hatteras in quest of the fish was undertaken for me by Dr. Maud L. Menten and Mrs. W. E. Lower. There twelve specimens were secured and preliminary studies made.

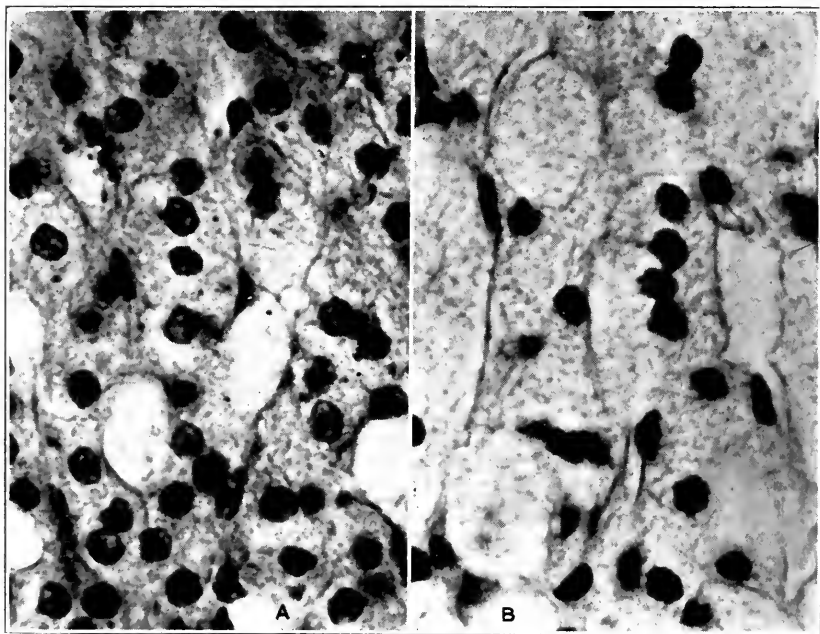


Fig. 5.—Effect of continuous exertion on the suprarenals of a cat; from photomicrographs  $\times 1640$ : *A*, section of normal suprarenal of a cat; *B*, section of suprarenal of a cat after continuous exertion for four hours. In *B* the general disappearance of cytoplasm, the vacuolation and the misshapen nuclei may be noted.

A later and more complete investigation was made by Dr. Menten at the Naples Marine Laboratory. In these studies, the electric current produced by the fish was conducted through a Thomson galvanometer (resistance, 30,000 ohms) and through a rheostat with a resistance varying from 0 to 1,000 ohms. The deflection of the galvanometer mirror reflected on a scale and was read by means of a telescope. During each experiment the fish was kept in a glass basin filled with sea water. The under surface of the fish rested on a zinc plate, and the second electrode of zinc covered with cotton was fitted over the

dorsal surface of the fish. From the two electrodes the current was conducted to the galvanometer and the rheostat.

Mechanical pressure over the caudal fins or directly over the electrical organ itself was found to be the most effective stimulation. When the animal became partially fatigued no response was elicited by mechanical stimulation over any other part of the fish. Only mechanical stimulation was possible, and as far as it was practicable the strength of this was kept approximately constant.

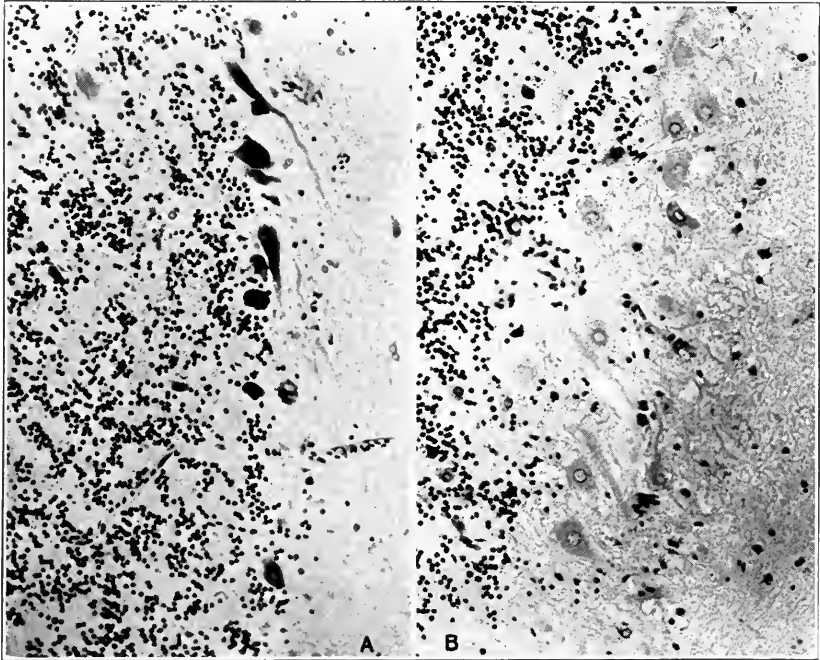


Fig. 6.—Effect of prolonged exertion on the brain cells of a salmon, from photomicrographs  $\times 310$ : *A*, section of the cerebellum of a salmon taken from the ocean at the mouth of the Columbia River; *B*, section of the cerebellum of a salmon taken from the headwaters of the Columbia River immediately after its passage from the ocean.

In each experiment, the stimulation was continued until no further current was elicited according to the evidence of the galvanometer mirror.

EXPERIMENT 1.—*Torpedo marmorata*, male, 20 inches long, active.

First Day: The rheostat resistance was 1,000 ohms. Mechanical stimulation of the animal over the entire dorsal surface (not limited to caudal fin or organ) was continued from 4 p. m. until 5:15 p. m., at the end of which time there was no response of galvanometer mirror, with a rheostat resistance of 100 ohms. The deflection of the mirror was between 5 and 8 divisions of scale.

Second Day: The fish had rested during the night in an aquarium. On the afternoon of the second day, it was stimulated over the dorsal surface for one hour (rheostat resistance 1,000 ohms). No appreciable difference in deflection was noted at the end of this time.

Third Day: The fish had been allowed to rest over night, and on the morning of the third day was stimulated mechanically over the dorsal surface from 10 a. m. till 12:30 p. m. and again from 3 p. m. to 4 p. m. At the termination of the latter period, there was no perceptible movement of the galvanometer mirror with a rheostat resistance of 10 ohms. Neither were shocks perceptible to the hand. The fish was practically moribund.

EXPERIMENT 2.—*Torpedo ocellata*, male, 12 inches long, was stimulated continually over the caudal fins and over the electric organ for two hours. At the end of this period, with resistance in the rheostat reduced from 1,000 ohms

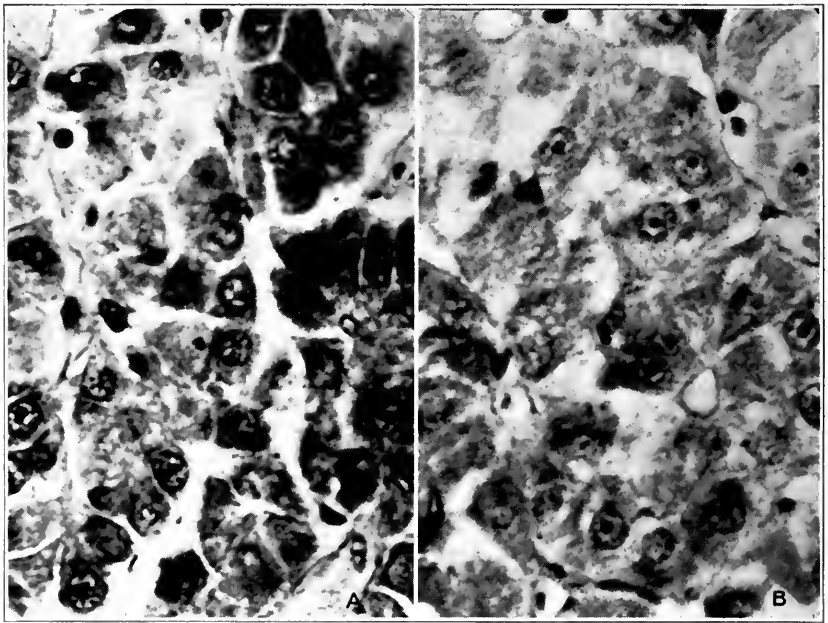


Fig. 7.—Effect of prolonged exertion on the liver of a salmon, from photomicrographs  $\times 1640$ : *A*, section of the liver of a salmon taken from the ocean at the mouth of the Columbia River; *B*, section of the liver of a salmon taken from the headwaters of the Columbia River after its passage from the ocean. The general loss of cytoplasm and the comparatively few nuclei in *B* may be noted.

to 0, the deflection of the galvanometer mirror was the same as at the beginning of the experiment; that is, the sensitiveness of the fish to response had been lessened 1,000 times. When the cord of the fish was severed at the end of the experiment, a barely perceptible electric shock was felt.

EXPERIMENT 3.—*Torpedo ocellata*, male, 11 inches long, active, was mechanically stimulated over the caudal fins and its electric organ for one and three-quarters hours. At the end of this period, no response was perceptible in the galvanometer, though the rheostat resistance was reduced to zero. The rheostat

resistance at the beginning of the experiment was 1,000 ohms and the corresponding deflection was from 21 to 11 scale divisions.

EXPERIMENT 4.—*Torpedo ocellata*, male, 13 inches long. At the beginning of the experiment with the rheostat resistance at 1,000 ohms, the deflection of the needle was from 21 to 18 divisions. At the end of two and a quarter hours of continuous stimulation by means of a glass rod over the caudal fins and the electric organ, no deflection of the galvanometer mirror was recorded with 0 ohms resistance. When at the end of the experiment, the cord was severed, a slight shock was perceptible to the wet hand.

EXPERIMENT 5.—*Torpedo ocellata*, female, 15 inches long, containing embryo with a large amount of attached yolk material.

With an initial rheostat resistance of 1,000 ohms, a deflection of the galvanometer mirror from 21 to 14 divisions was obtained. After continuous stimu-

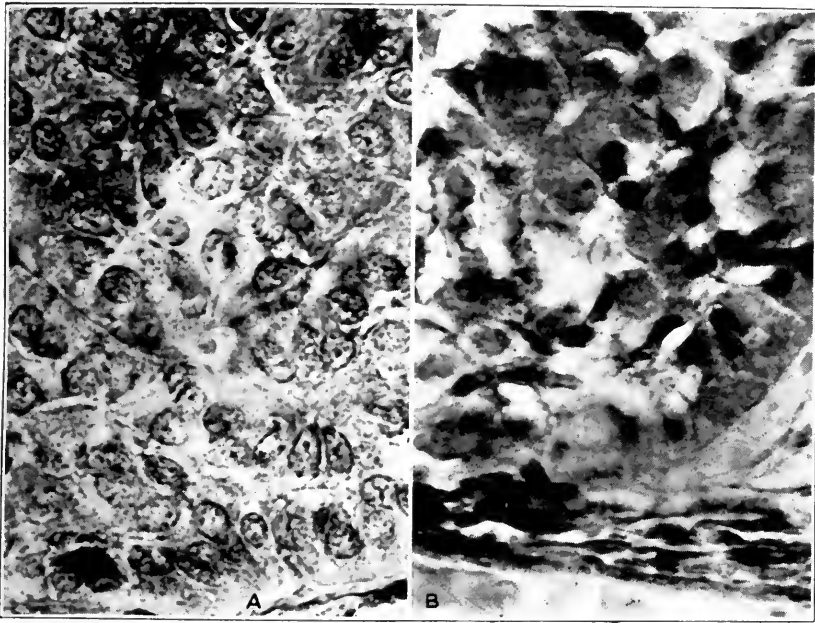


Fig. 8.—Effect of prolonged exertion on the suprenals of a salmon, from photomicrographs  $\times 1640$ : *A*, section of a suprarenal of a salmon taken from the ocean at the mouth of the Columbia River; *B*, section of a suprarenal of a salmon taken from the headwaters of the Columbia River after its passage from the ocean. The vacuolization and the generally disorganized appearance of *B* may be noted.

lation for two hours, no response could be obtained, even with no resistance in the rheostat. Repeated tests from time to time as in Experiments 3 and 4 showed a gradual decrease in the strength of the shocks. No shock was perceptible to the hand when the fish was removed from the water or when the cord was severed.

EXPERIMENT 6.—With an initial resistance of 1,000 ohms, stimulation gave a deflection of the galvanometer needle from 21 to 10 divisions. After continuous stimulation for one and one-half hours over the electric organ and the caudal

fin, there was no deflection of the galvanometer mirror even with no resistance in the rheostat. Throughout the course of the experiment, there was a gradual decrease in the amount of electricity given off by the organ, as shown by the necessity for continuous reduction of resistance in the rheostat.

At the end of the experiment when the fish was killed, no shock was perceptible, though there was a considerable contraction of the caudal muscles.

No differential cell counts were made but the photomicrographs (Fig. 9) portray graphically the histologic effect of the exhaustion produced in the brains of these fish by the repeated discharges of their stored electric energy.

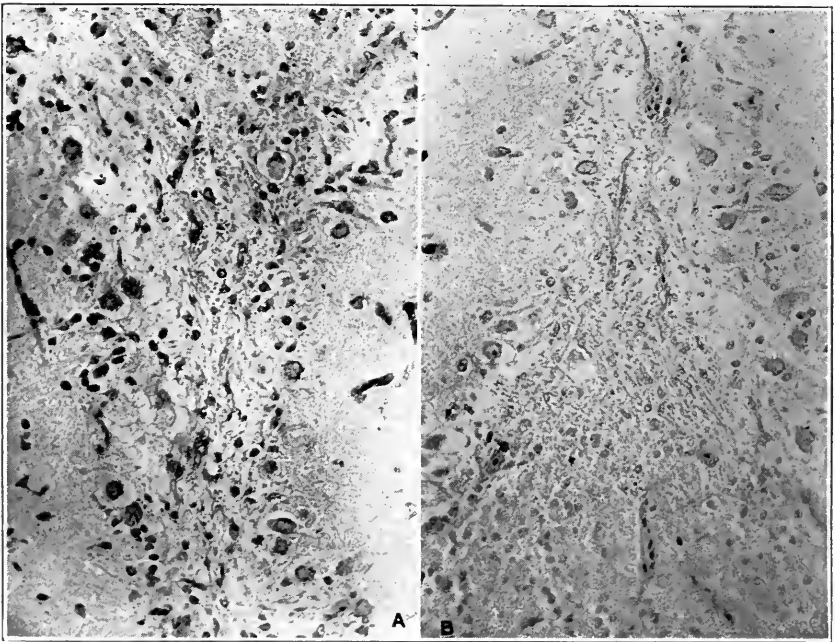


Fig. 9.—Effect on the brain cells of electric fish of the repeated discharges of its electric mechanism, from photomicrographs  $\times 310$ : *A*, section of the normal cerebellum of an electric fish; *B*, section of the cerebellum of an electric fish after repeated discharge.

An analysis of the analogy between the mechanism of muscular defense and of electric defense as exhibited in the electric fish elicits various significant facts:

(*a*) The battery of the electric fish can be recharged only during sleep. The energy of the brain is restored only during sleep.

(*b*) The ability to charge the battery and the ability to store energy in the brain are alike dependent on food.

(c) Repeated demands on the electric battery exhaust the battery and the fish; repeated demands on the energy stored in the brain exhaust the cells and the animal.

(d) Prolonged consciousness, exertion, emotion in animals cause lesions in the brain identical in character with the lesions in the brain of the electric fish caused by electric discharge.

These facts suggest that the mechanism of the animal in which muscular force predominates, and the mechanism of the animal in which electric force predominates are operated along similar lines.

## B. PHYSIOCHEMICAL STUDIES

### CHEMICAL CONTENT OF CERTAIN TISSUES

In order to determine the effect of exertion on the chemical contents of certain organs and tissues, various glands and tissues from eight normal cats and from the same number of cats which had struggled against restraint for four hours were analyzed by the experimental department of Parke, Davis & Co.

The animals were killed by stabbing. The glands and specimens of tissue were immediately excised and packed in chilled glass jars which were sealed and at once packed in ice. From eight to twelve animals were used for each of these experiments to secure a sufficient mass of gland material for measurable determinations. By the courtesy of Dr. Houghton and Messrs. Biggs, Hamilton and Rome of the Parke, Davis Company, the analyses were made in their laboratory by the following methods:

*Suprarenals.*—"The glands were first carefully examined to eliminate extraneous matter. They were then ground in a mortar with sand and transferred to a flask with twenty times their weight of water, to which 0.1 per cent. glacial acetic acid was added. This was heated in a boiling water bath for one hour, chilled in a refrigerator for fifteen hours, filtered and adjusted to a volume dilution, 1 c.c. of which represents 0.04 gm. fresh gland material.

"The assay of the suprarenal extract was carried out in the customary way by determining the pressor principle on anesthetized dog in comparison with a solution of epinephrin chlorid 1-1000."

*Thyroid.*—To avoid handling, the thyroids were not dissected from the trachea before shipment. At the Parke, Davis laboratory they were dissected from the trachea to secure the gross weight and were then combined with the trachea and desiccated by drying them at from 60 to 70 C., the total iodine being estimated by fusing the entire glands with fusing mixture and estimating the iodine by Hunter's method.

*Muscle and Liver.*—"The method used for determining the glycogen content appears in *Chemical Abstracts* (5:1929, 1911) being an abstract of the article of Edward Pflüger (*Arch. f. d. ges. Physiol.* **129**:362-378 and *Chem. Zentralbl.* **2**:1381-1382, 1909).

"In the course of the manipulation of this method it is necessary to precipitate the glycogen with alcohol. It is also necessary to filter this precipitate

and wash the filtrate with a certain strength of alcohol. Such manipulation as this cannot be quantitative and so we hesitate to place any great amount of reliance on the accuracy of the results submitted herewith. There is more or less evaporation of alcohol depending upon the length of time that it takes to carry out the filtration and hence the alcoholic strength keeps changing and the solubility of the precipitate keeps increasing as the alcohol evaporates."

The results of these studies are summarized in Table 9.

TABLE 9.—CHANGES IN THE CHEMICAL CONTENT OF CERTAIN TISSUES DUE TO PROLONGED EXERTION

	Thyroid	Suprarenals		Liver	Muscle
	Iodin Content, per Cent.	Epinephrin Content, per Cent.	Epinephrin Activity, per Cent.	Glycogen Content, per Cent.	Glycogen Content, per Cent.
Eight normal cats.....	0.000156	1	5	0.508	0.56
Eight cats after vigorous exertion for four hours.....	0.000331	0.066	3	0.576	Trace

#### H-ION DETERMINATIONS

In three experiments, the H-ion concentration of the blood was found to be increased after brief and after prolonged periods of violent exertion, as is shown by Table 10.

TABLE 10.—EFFECT OF EXERTION ON THE H-ION CONCENTRATION OF THE BLOOD

Exp.	Animal	Normal	Length of Exertion	pH after Exertion
1	Dog.....	7.54	Brief struggle	7.49
		7.52		
2	Dog.....	7.5	1 hour	7.45
3	Same as 2 used on following day.....	7.40	2½ hours	7.38
			5¼ hours	7.30

#### C. CLINICAL NOTES

The gross clinical results of overexertion are obvious enough to every observer. The resultant exhaustion from one brief seance of intense exertion may be so extreme as to cause immediate death, as was the case with the first Marathon runner and as has been the lot of some of his successors. Or in other instances, it may leave the individual permanently impaired, as again happens frequently in the case of race horses and athletes. The race horse reaches his maximum speed but once, and the winner of this year's Marathon may not be among the first in next year's race.

In like manner overexertion of a lesser degree destroys permanently some of the units of energy production.



Clinical observations on a race horse during successive preliminary heats and during a race were made for me by a veterinary surgeon, as shown in Table 11.

TABLE 11.—CLINICAL OBSERVATIONS ON A RACE HORSE BEFORE, DURING AND AFTER A RACE (WEATHER COOL)

	Temperature	Pulse	Respiration
At rest during morning before race.....	99.4	42	16
Immediately after first preliminary heat—mile in 2:40...	100.3	72	84
25 minutes later.....	100.0		
Immediately after second preliminary heat—mile in 2:25	101.3	84	80
25 minutes later.....	100.0		
Immediately after third preliminary heat—mile in 2:14..	102.2	90	92
40 minutes later.....	99.3		
Race			
Immediately after first heat—mile in 2:08½.....	101.4	90	84
25 minutes later.....	100.4		
Immediately after second heat—mile in 2:06¼.....	102.4	84	76
25 minutes later.....	103.0		
Immediately after third heat—mile in 2:07.....	104.0	72	78

After races "cooling out" temperature taken every half hour: 101.3, 101, 100, 99.4.

### E. CONCLUSIONS

1. Extreme physical exertion in various land animals and in fish causes demonstrable histologic lesions in the central nervous system, the liver and the suprarenals, these changes being least marked in the liver. These histologic changes are identical in character with those already described as due to prolonged insomnia.

2. The discharge of the electric mechanism in the electric fish causes histologic lesions in the brain, the liver and the suprarenals of that fish.

3. Chemical studies made after animals had been subjected to extreme exertion show an increased iodine content of the thyroid, and slightly increased glycogen content in the liver; a diminished glycogen content in the muscles; greatly diminished epinephrin content and a diminished epinephrin activity.

4. The hydrogen-ion concentration of the blood and of the urine is increased by extreme exertion.

5. The clinical effects of exertion as immediately manifested in increased temperature, pulse and respiration, and later in acute or chronic exhaustion are self-evident.

Euclid Avenue and Ninety-Third Street.

# THE COURSE OF RECOVERY FOLLOWING TRAUMA OF THE SPINAL CORD\*

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BOSTON

RICHMOND, VA.

This paper is written not with the idea of presenting new facts in regard to spinal cord injuries but with the intention of emphasizing by graphic methods the usual course of recovery in these cases. So much careful work on the symptomatology and physiology of spinal cord lesions has been published recently that the reader is referred to the papers by Riddock, Head, and Holmes for this material.

For this study, twenty patients with spinal cord injury were selected as they were admitted to U. S. Army General Hospital No. 11 between Oct. 1, 1918, and Feb. 1, 1919. Their histories were analyzed, repeated physical examinations were made, and the general condition of the patient was followed in a routine way. A short summary of each case is given herewith:

## REPORT OF CASES

*CASE 1.—History.*—N. K. was wounded, Sept. 26, 1918, by a piece of an aerial bomb which entered the neck anteriorly in the midline and did not emerge. The left arm was immediately paralyzed and the legs were weak although he was able to walk. There was no fracture. There was a partial Brown-Séquard syndrome. The weakness of the legs lasted about four months, when he was discharged and able to work except for weakness of the left arm, accounted for by a brachial plexus injury. The only bladder symptom was slight urgency of urine for sixty days.

*Diagnosis.*—Contusion of the spinal cord at the level of the eighth cervical segment, more on the left than the right.

*CASE 2.—History.*—W. D. was wounded Sept. 26, 1918. There was an immediate partial paralysis of both arms which cleared up in about three months. He was incapacitated for only about three weeks, the residual at the end of three months amounting merely to increased reflexes. There was no weakness of the legs, only slight spasticity.

*Diagnosis.*—Probably a contusion of the spinal cord at the level of the eighth cervical segment. There were no bladder or urinary symptoms. He was discharged well.

*CASE 3.—History.*—S. E. was wounded, July 14, 1918. There was an immediate paralysis of the left arm due to a brachial plexus injury; there was no disturbance in the motion of the legs but marked pain in both legs for several weeks and slight spasticity. At the end of six months, he was completely well except for the brachial plexus injury. The bladder disturbances were retention of urine for three days and impotency for thirty days.

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\* From the Surgical Service of Lieut.-Col. Frazier, U. S. A. General Hospital No. 11, Cape May, N. J.

*Diagnosis.*—Contusion of the spinal cord at the level of the eighth cervical segment.

CASE 4.—*History.*—F. M. was wounded, July 18, 1918, by a machine gun bullet striking him in the left cheek and ranging downward to come out just to the left of the spinal column in the back of the neck. He was immediately completely paralyzed in all four extremities; but in two weeks he could move his legs and right arm. After seven weeks he could stand by holding on to the bed and in three months he could walk a mile. His bladder was not affected; but he was impotent for ten months and had constipation and precipitant defecation for nine months. The roentgen-ray showed a fracture of the fifth cervical vertebra.

*Diagnosis.*—Contusion of the spinal cord at the level of the seventh and eighth cervical segments.

CASE 5.—*History.*—H. W. was wounded, Sept. 22, 1918, an immediate partial right hemiplegia developing which remained stationary for four weeks and then rapidly improved until at the end of six months he was practically well, having only a slight residual spasticity in the right arm and leg. There were no bladder, rectal or sexual symptoms. Physical examination revealed a partial Brown-Séquard syndrome. There was no fracture.

*Diagnosis.*—Contusion of the right side of the spinal cord at the level of the fifth to the eighth cervical segments.

CASE 6.—*History.*—A. F. B. was wounded, Sept. 26, 1918. He was immediately completely paralyzed in both legs, and there was loss of sphincter control. After three weeks, the paralysis began to improve, and in two and a half months, he was able to walk several miles and was bothered only by slight spasticity. There was incontinence of urine for sixty days with urgency and slight lack of control for three months more. He was unable to control his bowels for two and a half months after the wound, and for five months there was constipation. There was no fracture.

*Diagnosis.*—Contusion of the cord at the level of the sixth dorsal segment.

CASE 7.—*History.*—J. T. was wounded, July 1, 1918, by a piece of shrapnel striking him in the neck. It entered above the inner third of the right clavicle and lodged against the spinal column, fracturing the transverse process of the seventh cervical vertebra. For one month he was completely paralyzed in both legs but then began to improve, and at the end of two and a half months he was able to walk a mile and was well except for slight stiffness of the legs at the end of four and a half months. He had retention of urine for thirty days, incontinence for three weeks more, and then urgency for three months. There was cystitis as long as he was under observation. The control of the rectal sphincter was incomplete for four and a half months, and he was sexually impotent for five months.

*Diagnosis.*—Fracture of the seventh cervical vertebra with contusion of the eighth cervical segment, more on the right than on the left causing a partial Brown-Séquard syndrome.

CASE 8.—*History.*—R., June 19, 1918, received a gunshot wound of the neck. There was immediate complete paralysis of all four extremities, but in three weeks he began to be able to move the right arm and leg; in five weeks, the left leg, and in six weeks, the left arm. Improvement was rapid for four months, at the end of which time he could walk several miles but needed some support with a cane. At the end of eleven months, there were no symptoms left except slight spasticity of the right arm and leg. There is no history of retention of urine; but for ten months there was slight incontinence and sexual

impotency, while for seven months he was constipated. There was a fracture of the fifth cervical vertebra.

*Diagnosis.*—Contusion of the spinal cord at the level of the sixth and seventh cervical segments with partial Brown-Séquard syndrome.

CASE 9.—*History.*—S. G. R., July 15, 1918, received a gunshot wound in the lower back. He was completely paralyzed for five days in both legs; then the toes of the left foot began to move. The left leg could be moved in one month and the right leg in about two months. He could first walk across the room at this time with support, and by the end of the fourth month he could walk more than a mile without support. His bowels were incontinent for thirty days, and there was retention of urine for the same period. For two months more there was slight incontinence with enuresis. Sexual power first returned sixty days after the injury. There was no fracture of the spine.

*Diagnosis.*—Contusion of the cord at the level of the fourth lumbar segment.

CASE 10.—*History.*—C. L. J., July 28, 1918, received a gunshot wound in the lower back. There was complete paraplegia for two weeks and then slight return of power in the right foot. In two and a half months, he could walk a few steps with support and at the end of four months he could walk a mile. There was retention of urine for two months with incontinence for one month more and following this about forty days of incomplete control. There was no fecal incontinence but constipation was marked for four months. Sexual impotence was the most marked symptom and lasted for five months.

*Diagnosis.*—Fracture of the spine with contusion of the third and fourth lumbar segments.

CASE 11.—*History.*—S. J. P. was wounded, July 18, 1918. He was immediately paralyzed in the left leg with partial paralysis of the right leg. There was loss of sphincter control in the bladder for thirty days and of the rectum for four months. Sexual power, however, did not return for eight months. The paralysis began to improve after one and a half months, and he could walk at the end of three months. When discharged six months after the injury he was able to walk more than a mile without support. There was a fracture of the fourth lumbar vertebra.

*Diagnosis.*—Contusion and compression of the cauda equina.

CASE 12.—*History.*—W. J. received a gunshot wound of the neck, July 30, 1918, causing a fracture of the seventh cervical vertebra with partial paralysis of all four extremities, which remained stationary until he was operated on three months later and a foreign body removed from the spinal canal. This was pressing on the posterior part of the cord slightly more on the left than on the right, causing a partial Brown-Séquard syndrome. After the operation, there was marked improvement and he was able to walk a mile at the end of seven months. His bladder, rectum and sexual functions were at no time disturbed.

*Diagnosis.*—Fracture of the seventh cervical vertebra with contusion and compression of the eighth cervical and first dorsal segments.

CASE 13.—*History.*—W. H., July 19, 1918, received a gunshot wound in the abdomen which fractured the fifth lumbar vertebra causing complete paralysis of the left leg and partial paralysis of the right. This showed no improvement for two weeks, and then he gradually regained power and was able to walk at the end of the fourth month. He was incontinent of urine for ten months, incontinent of feces for eight months and had severe constipation for the whole ten months; but sexual power returned at the end of the fourth month.

*Diagnosis.*—Fracture of the fifth lumbar vertebra with injury of the cauda equina.

CASE 14.—*History.*—B. F. S. was wounded, Sept. 30, 1918, by a machine gun bullet which struck him in the side of the neck and fractured the eighth cervical vertebra, causing immediate paralysis of both legs. This remained complete for one and a half months and then gradually improved up to the end of the second month, after which improvement became more rapid so that he could walk across his room in the third month and walk a mile at the end of the fourth. For fourteen days, he was incontinent of feces; for twenty days there was retention of urine and for eighty days incontinence. At the time of the last examination, there was still some incomplete control. The first signs of sexual power returned at the end of the eighth month.

*Diagnosis.*—Fracture of the eighth cervical vertebra with contusion of the first and second dorsal segments.

CASE 15.—*History.*—V. N. was wounded, Aug. 7, 1918. He was immediately paralyzed in both legs and showed his first improvement at the end of one and a half months. At the end of the second month, he could take a few steps with support; but in the eighth month he could walk across his room only two or three times. There was no fracture. The rectal sphincter was incontinent for one month; there was retention of urine for one week with incontinence for four months; and at the time of the last examination there was still incomplete control.

*Diagnosis.*—Hematomyelia of the third and fourth lumbar segments of the spinal cord.

CASE 16.—*History.*—C. M. received a gunshot wound, June 5, 1918, in the lower back, which caused a fracture of the first and second lumbar vertebrae and immediate paralysis of both legs. There was no improvement for six months. In the seventh month he could stand without support, and at the last examination, ten months after injury, he could take a few steps with help. The rectum showed incontinence for four months, and there was still marked constipation at the last examination. There was retention of urine for forty days, incontinence for eight months and urgency when last examined. Sexual power returned at the end of three months.

*Diagnosis.*—Fracture of the first and second lumbar vertebrae with injury to the cord and cauda equina.

CASE 17.—*History.*—D. M. received a gunshot wound of the spine, July 20, 1918, which fractured the last dorsal and first lumbar vertebrae. There was immediate complete paralysis of both legs which showed no improvement until the eighth month when he was given orthopedic treatment and improved enough so that in the tenth month he could stand up with support. His rectal sphincter was incontinent for nine months and then regained some control. There was complete urinary incontinence for three months, improving during the next six months.

*Diagnosis.*—Injury of the spinal cord at about the fourth lumbar segment with fracture of the twelfth dorsal and first lumbar vertebrae.

CASE 18.—*History.*—H. G. was wounded by a machine gun bullet, July 18, 1918. This struck him in the abdomen, passing through and fracturing the second lumbar vertebra. There was immediate and complete paralysis of both legs, which had showed no improvement at the end of the tenth month. Marked cystitis was present practically the whole time. He was entirely incontinent of urine and feces, and there was no return of sexual power.

*Diagnosis.*—Partial interruption of the spinal cord at the level of the fourth lumbar segment with fracture of the second lumbar vertebra.

*CASE 19.—History.*—W. J. P. was wounded, Aug. 9, 1918, by a machine gun bullet which fractured the twelfth dorsal vertebra, causing a complete paralysis of both legs with entire loss of sphincter control and sexual power. There was marked cystitis from the first weeks of the disease and no improvement whatever at the end of the tenth month.

*Diagnosis.*—Fracture of the twelfth dorsal vertebra and incomplete interruption of the spinal cord at about the level of the fourth lumbar segment.

*CASE 20.—History.*—M. T. was struck in the back of the neck with a piece of high explosive shell, June 4, 1918. This fractured the sixth cervical vertebra and lodged in the vertebral canal. He was immediately completely paralyzed in all four extremities. About six weeks later, voluntary movement began to return in both arms and one month later in the left leg. The right leg did not improve until the sixth month. In spite of this slight return of motion, he could not even stand up at the end of the seventh month so a laminectomy was performed and the foreign body removed from the vertebral canal where it was pressing on the right posterior aspect of the cord. In the next three months, there was slight improvement in the motion of the legs. After the operation there was, however, immediate improvement in the control of the bladder, which up to this time had been entirely incontinent, and sexual power returned at the same time. He had fecal incontinence for the first five months, which improved spontaneously.

*Diagnosis.*—Fracture of the seventh cervical vertebra with contusion and compression of the first and second dorsal segments of the cord.

#### COMMENT

Of the twenty cases under consideration, eight patients had lesions of the cervical cord, two of the dorsal, eight of the lumbosacral cord and two of the cauda equina. Six showed more or less distinct symptoms of unilateral lesions (that is, a Brown-Séquard syndrome). These were all mild cases (Cases 1, 3, 5, 7, 8, 12); and all these patients were wounded at the cervical level. The chart shows that all of these men had rapid and fairly complete recoveries except one (Case 12) in whom a foreign body was left in the spinal canal and not removed for three months; but after operation the curve of recovery is seen to rise steadily for five months.

No general rules could be laid down concerning bladder, rectal or sexual symptoms. The accompanying tabulation of these symptoms showed no conspicuous correlations. Some points, however, seemed to be significant.

Of the six patients showing partial Brown-Séquard syndromes, four had no disturbance at all of the sacral autonomic system while two showed disturbances. In one (Case 7), although the lesion was cervical, the hemiplegia began improving in twenty days and recovery was practically complete in three months. The bladder symptoms were severe. There was retention of urine for thirty days, incontinence for fifty days and poor control of micturition with urgency for five months.

He was impotent sexually for a similar period, and had difficulty retaining his bowel movements for four and a half months after the injury.

In Case 8—a cervical lesion with remarkable recovery from an at first complete quadriplegia—there was slight incontinence of urine for ten months, constipation for seven months and impotence for ten months.

In another severe cervical injury (Case 14) there was retention of urine for twenty days with incontinence for the two months following, and urgency and poor control remaining after nine months. He had his first erection eight months after the injury. His bowels were incontinent for two weeks and then constipated for nine months.

BLADDER AND RECTAL SYMPTOMS FOLLOWING INJURIES TO THE SPINAL CORD

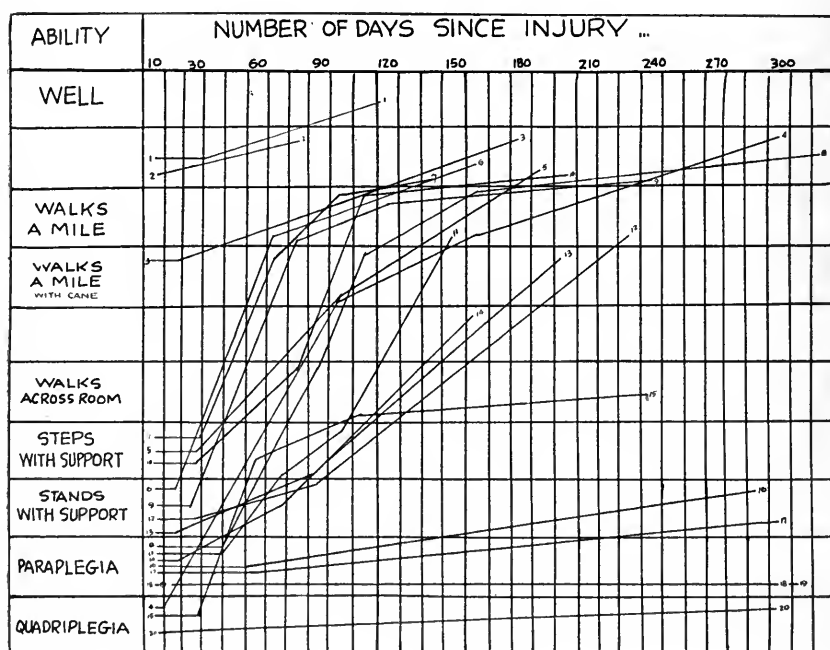
Name	Case	Retention of Urine, Days	Incontinence of Urine, Days	Urgency of Urine, Days	Cystitis, Days	Impotency: Inability to Have Erection, Days	Incontinence of Feces, Days	Constipation and Poor Control of Bowels, Days	Level of Lesion	General Condition
J. T.	7	30	50	140	140	150	Slight for 140	?	C <sub>8</sub>	Hemiplegia for 20 days, then rapid improvement
R.	8	0	Slight for 300	0	0	300	0	200	C <sub>6</sub>	Quadriplegia complete 3 weeks, gradual great gain in 320 days
C. L. J.	10	60	90	120	?	150	0	120	L <sub>3</sub>	Paraplegia 60 days, then rapid recovery
W. H.	13	?	300	300	300	120	240	300	Cauda equina	Paraplegia for 20 days, then gradual improvement
B. F. S.	14	20	80	270	270	240	14	270	C <sub>8</sub>	Paraplegia for 20 days, then gradual improvement
C. M.	16	40	240	300	300	90	120	300	L <sub>2</sub>	Paraplegia 170 days, slight slow improvement

As a rule, however, only the severe cervical injuries showed any of these symptoms, whereas all the lumbosacral and cauda equina injuries showed them in severe form even though the motor paralyses were comparatively unimportant (Cases 10, 11, 13, 15). The cases indicate that in the cervical injuries the sexual function suffers relatively more than the urinary or rectal, while in the lower injuries the sexual potency may return while there is still incontinence of urine and feces (compare Cases 13 and 16 with Cases 7 and 14). In only one case in which there was bladder disturbance was cystitis entirely avoided. All the other patients were catheterized and infected for shorter or longer periods. If some of the patients that later showed rapid recovery could have been spared this, much trouble would have been avoided.

Incomplete as the data often were, enough facts were available to construct the accompanying chart, which roughly indicates the course of the illness following gunshot wounds of the spinal cord. A glance

at this chart reveals that the cases can be divided into three groups: first, the upper group of three in which the injury to the cord was insignificant and was found only in the course of a routine examination; second, the central group (Cases 4 to 15) in which the injury at first caused marked disability, often a complete paraplegia, but with good recovery; and third, the last five cases which were all severe and permanent injuries of the cord, although in none was the cord completely divided.

The second group shows several points of interest. In the first place, all of these patients appeared to have a severe injury at first, and for a period of from ten to forty days the symptoms remained station-



Course of illness following gunshot wounds of the spinal cord.

ary with complete hemiplegias, paraplegias or quadriplegias. During this time many of the patients were even told by their attending surgeons that they would "never walk again." Then the improvement suddenly began and progressed rapidly for three or four months, when a level of recovery was reached that was seldom greatly bettered thereafter. In other words, if after an injury to the spinal cord no recovery is demonstrable in sixty days the outlook is bad. Moreover, most of the patients that are to improve to any great extent begin to do so during the first forty days. Then during the next four months rapid recovery



takes place and thereafter the condition remains comparatively stationary. A prognosis and estimate of disability can then be quite accurately made, and the permanent residual paralysis noted. These residuals were varied. There were many brachial plexus injuries with the cervical cord lesions. Several patients showed the oculopupillary changes that accompany lesions of the cervical sympathetic nerve or its center in the cord. Root lesions were common accompanying vertebral fractures.

From the surgical standpoint, the question of whether to operate or not is important. And, if operation is advisable, when is the best time? It may be argued that the patients should be left alone until they have recovered as much as possible without operation. But then how can we say that an early decompression of the cord would not have relieved pressure during the stage of edema and bleeding and thus have conserved many cells that were later permanently damaged?

One of the most important questions raised by the study of these patients is whether or not the late results would be better if early operation were performed. The decision for or against early operation would be less difficult if the cases with partial lesions which show complete physiologic interruption were clinically distinguishable from those with complete anatomic lesion. This study shows that it is often impossible to classify spinal cord injuries clinically with reference to the extent of the cord destruction, and many cases which at first are regarded as hopeless may require regrouping later, because of the appearance of signs indicating a resumption of cord function. Recovery of function in such cases may progress to an almost complete restoration (Case 4). In view of the difficulty of determining early which cases have a complete anatomic transection and which have edema, hemorrhage, and compression superimposed upon an incomplete lesion, it does not seem justifiable to delay operation in all cases in which there appears to be a complete physiologic interruption. If an operation is withheld until some signs of recovery of cord function appear, additional damage to the cord may result. The residuals, then, could be attributed in part to the failure to offset the pressure effects by early decompression. Thus it is probable that the conservatism advocated by some in the treatment of severe cord injuries should be modified. If the patient's general condition justifies an operation, an effort should be made to reduce or prevent the later disabilities by prompt exploration of the injured cord provided a reasonable doubt exists as to whether or not the cord is completely divided.

# FRACTURE OF THE SKULL

IMPORTANCE OF THE EARLY DIAGNOSIS AND OPERATIVE TREATMENT OF  
FRACTURE OF THE SKULL, WITH CHART OF CLINICAL CLASSIFICA-  
TION AND TREATMENT, AND GUIDE FOR DETAILED NEUROLOGIC  
EXAMINATION

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## SYNOPSIS

This paper is an effort (*a*) to establish a routine examination for all head injuries possibly associated with fractures, and (*b*) so to classify fractures that a more or less definite policy of treatment may be followed.

The recommendation is made that the house surgeons of all hospitals be instructed that, on admission, these measures should be carried out:

1. All wounds of the scalp which may possibly be associated with a fracture of the skull must be routinely excised and the adjacent bone examined for fracture, which, if found, can by the excision of the infected area be converted from a compound into a simple fracture.

2. All possible fractures of the skull must be subjected to a routine method of examination, every case being (*a*) routinely and systematically examined neurologically; (*b*) the blood pressure routinely taken, at least every hour, for several hours after the injury; (*c*) a lumbar puncture routinely performed; (*d*) repeated ophthalmoscopic examinations routinely made, and (*e*) roentgenograms routinely taken, with, if necessary, exposures in different positions.

With the data obtained by this routine examination, a rather definite policy of treatment may be pursued, such data largely deciding which cases require, and which do not require, an intradural operation.

## NECESSITY FOR SPECIAL TECHNIC IN TRAUMATIC INTRACRANIAL SURGERY

Until recently, traumatic intracranial surgery was in the hands of the general surgeon, who usually had no special training for its performance and brought to it habits of technic which not only were totally inadequate to meet the problems presented, but frequently occasioned additional damage to the delicate cerebral tissue, with resulting permanent disability to the patient.

In the early days of the war, it was stated that "it would have been better if the cranial injuries had not been treated surgically, the operative manipulation of the general surgeons having done more harm than good."

The war evolved a thoroughly new understanding of fractures of the skull, and definite features in its treatment are now recognized as essential.

The routine treatment of cases of fracture of the skull, as carried out in the civil hospitals today, is largely of the prewar type. The policy generally followed is this: If the fracture is accompanied by slight symptoms, no operation is performed; no operative differentiation being made between simple and compound fractures. If the immediate cerebral symptoms are severe, an expectant treatment is pursued, unless the patient is in such a grave condition that life is despaired of or localizing symptoms are present. The latter symptoms of terminal compression and the secondary symptoms of meningeal infection, both of which are frequently avoidable by early surgical interference, are regarded as indications for operation, with necessarily a very high mortality.

*Remote Effects.*—Fracture of the skull results not only in immediate danger to life, but in remote and serious consequences, the patients later developing such severe and lasting symptoms that life becomes more or less unendurable.

Fracture of the skull accompanied by injury to the cerebral tissue or infiltration of blood into the brain substance, causing prolonged increase of the intracranial pressure, is frequently followed by a gliosis. Gliosis, the production of a new connective tissue within the brain, the result of an irritant, is not relievable by any known operative procedure. Chief among the symptoms of a secondary gliosis is persistent headache, for the relief of which a large number of useless operations are performed annually. Another is the development of traumatic epilepsy. Traumatic epilepsy is generally preventable by early operation; but epilepsy, the result of secondary gliosis, is not amenable to operative treatment.

*Classification.*—Fracture of the skull should primarily be divided into (a) simple and (b) compound fractures.

Simple and compound fractures of the skull present two fundamentally different surgical problems and require different lines of treatment.

*Surgical Principles of Treatment.*—In simple fractures, the surgical manipulations are limited to (a) the relief of increased intracranial pressure, and (b) the prevention of gliosis; while the surgical problems of compound fracture are primarily: (a) the prevention of intradural

sepsis, in addition to (*b*) the relief of intracranial pressure and (*c*) the prevention of gliosis.

The possibility of the associated cerebral trauma being irreparable, a frequent condition, has too often prevented an operation for the relief of cerebral compression.

The surgeon can do nothing to repair lacerated or damaged brain tissue; but if the cerebral compression is removed, Nature will frequently bring about a recovery from a cerebral injury which otherwise would end fatally. Consequently, as it is impossible to estimate correctly the extent of the brain laceration and as the relief of cerebral compression is the only surgical end attainable, the possibility of associated injury to the cerebral tissue should largely be disregarded.

Similarly, the dividing of fracture of the skull into bursting, bending, linear, or comminuted has largely confused the real surgical consideration, namely, whether the fracture is or is not depressed.

Linear fractures, simple or compound, cause no immediate symptoms unless associated with intracranial hemorrhage or injury to a nerve as it leaves the skull.

I have been impressed by the frequency with which linear fractures of the skull are overlooked, some being followed by distressing symptoms, avoidable by early recognition and operation.

A linear fracture of the base passing through the petrous portion of the temporal bone causes permanent deafness associated with distressing tinnitus or vertigo. It is because of the persistence of the vertigo following unrecognized fracture through the base that many of the patients first consult me.

*Neurologic Examination.*—Every case of cranial trauma, even though the acute symptoms rapidly disappear, should be subjected to a routine neurologic examination, which will frequently reveal positive evidence of fracture otherwise overlooked. (See Guide for Detailed Neurologic Examination for hospital interns, page 147).

#### DIAGNOSIS OF INCREASED INTRACRANIAL PRESSURE

*Importance of Systematic Blood Pressure Examination.*—The blood pressure of every patient with a possible fracture should be repeatedly taken, at least every hour for the first few hours, until a persistently rising blood pressure or pulse pressure is definitely excluded. An increasing intracranial pressure, sufficient to cause a persistently rising blood pressure, if not early recognized and relieved by operation, uniformly results in sudden death from respiratory paralysis.

CASE 1.—A man fell and struck his head while intoxicated. On admission he was in deep coma, which was thought to be largely the effects of alcohol. There were no external signs of fracture. Blood pressure was 160. A few

hours later Cheyne-Stokes' respiration developed; the pulse became strong and regular, and the blood pressure rose to 210.

*Necropsy.*—A fracture through the base with intradural hemorrhage was revealed. Immediate decompression might have saved him.

Of equal importance is an increasing disproportion between the systolic and diastolic blood pressure; namely, a disproportionally rising pulse pressure, usually associated with a falling pulse. A rising systolic blood pressure is seldom present unless the medulla itself is involved, but a rising pulse pressure is common in acute compression.

#### • LOW DIASTOLIC PRESSURE A CONTRAINDICATION TO OPERATION

If on admission the diastolic pressure is below 55, the patient is in profound shock. The slightest manipulation will then send the diastolic pressure a little lower, whence it will not rise. Before the restoration of the diastolic pressure to a higher level, no surgical procedure should be instituted. The patient should not be moved, disrobed, nor should his wound be dressed beyond what is absolutely necessary to control bleeding. He should be kept warm.

*CASE 2.*—This patient suffered a compound fracture of the temporal region. He was in excellent mental condition, conversing freely about the accident. The pulse was poor, as a result of his having lost considerable blood, which, however, had stopped at the time of examination.<sup>1</sup>

*Operation.*—Elevation of the depressed fracture was performed, uncovering a tear in the lateral sinus, which again bled freely. Hemorrhage was controlled by transplantation of a piece of fascia lata. The dura was not injured. During operation the anesthetist reported the patient was in a serious condition. Death occurred from shock, without the patient's regaining consciousness.

*Value of Ophthalmoscopic Examination.*—The fundus in every case of suspected fracture of the skull should be examined within the first few hours. This should be repeated daily as long as the diagnosis is in doubt. Systematic ophthalmoscopic examination may show moderate increase in the intracranial pressure when absolutely no other symptoms are present.

In my experience a typical "choked disk" is never seen in fractures of the skull. However, fulness of the vessels and a slight degree of blurring at the margin of the disk is always present with increased intracranial pressure. I have observed a primary blanching of the whole retina, probably from the ischemia of the vessels from shock, give place to a mild papillo-edema as the intracranial pressure rose from cerebral edema.

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1. This man's blood pressure was not taken. It is because of this case that I have since always insisted on a routine examination of the blood pressure, for I have no doubt that at the time of the operation the diastolic pressure was very low. Had this been shown we would not have operated.

*Lumber Puncture As a Diagnostic Measure.*—In all suspected fractures of the skull there should be performed a routine lumber puncture, blood in the fluid being presumptive evidence of intradural hemorrhage.

A type of intracerebral hemorrhage, not associated with bloody cerebrospinal fluid, is injury to the middle meningeal artery, the resulting hemorrhage being between the bone and the dura. Following an injury in which there is perhaps a moment or two of unconsciousness, later consciousness is entirely regained, "the free interval," followed by cerebral symptoms. These cases result most satisfactorily, providing operation is not deferred until a vascular breakdown is threatened.

CASE 3.—A boy fell from a window, was dazed but never unconscious, and then appeared perfectly normal. He walked into the hospital apparently not injured except for a bruise on the side of his head. There was no external wound. The following day, weakness of the arm developed; later, convulsion, followed by unconsciousness, with paralysis of one arm and leg. The roentgen ray revealed a linear fracture.

*Operation.*—This exposed the fracture involving the anterior branch of the middle meningeal artery. A thick, extradural clot was revealed, on evacuation of which, recurrence of bleeding from the tear in the middle meningeal artery occurred. This was ligated. The patient made an uneventful recovery.

*Lumbar Puncture as a Therapeutic Measure.*—In many cases of cerebral trauma the irritation from hemorrhage and cerebral disorganization occasions an increase in the cerebrospinal fluid, which adds to the already increased intracranial pressure. This "vicious circle" may be broken by a lumbar puncture.

CASE 4.—A man suffered a fracture of the skull. He was in deep coma; there was intense papillo-edema, and bloody cerebrospinal fluid under pressure; a depressed fracture over the temporal region with a tear in the lateral sinus.

*Operation and Result.*—A large extradural clot was evacuated. Hemorrhage was controlled by ligation of the sinus. Three weeks later the patient was semicomatose, delirious, restless and controlled only by restraint. There was marked papillo-edema. Lumbar puncture liberated a large quantity of cerebrospinal fluid under pressure. There was immediate improvement. The second puncture was followed by permanent relief.

*Roentgen-Ray Examination.*—A routine roentgen-ray examination of all head injuries frequently discloses very extensive fractures, even going beyond the median line, unassociated with any symptoms. It is necessary, however, that a negative roentgen-ray finding should not be taken as positive evidence of the absence of fracture. Several exposures in different positions may be necessary to demonstrate the presence of a fracture even when it is depressed.

CASE 5.—A woman was struck on the top of the head and over the left eye. When she was admitted to the hospital, there was a wound in both regions. The upper one was excised, the lower one sutured without excision. The first roentgen-ray diagnosis was: "Possible fracture of the skull." It was not until the third roentgenogram that a diagnosis of depressed frontal fracture was made.

CASE 6.—A man was struck on the head, probably by a sandbag, while semi-intoxicated. On admission, he was in semicoma, thought to be largely alcoholic in origin. There was slight hemorrhage from the ear; the blood pressure was 140. Lumbar puncture revealed slightly bloody cerebrospinal fluid under pressure. The following morning he was conscious and rational. The blood pressure was 160. Four hours later the blood pressure was 170. There were no cerebral symptoms except that the man talked rather too freely, appeared nervous and wanted to leave bed. The hemorrhage from the ear was thought to be from the external canal as he heard well. There was mild papillo-edema, accounted for by cardiovascular disease, which was otherwise manifest. The roentgenogram was negative. Clinical diagnosis was delirium tremens. Twenty hours after admission, the blood pressure was 200. He was taken to the operating room, thought to be suffering from alcoholism. In view of the rising blood pressure it was decided that if the cerebrospinal fluid was found to contain blood a decompression operation would be performed. He was given ether because he could not be restrained. On removing some cerebrospinal fluid, the heart suddenly stopped.

*Necropsy.*—There was separation of the lambdoid suture and a linear fracture of the left petrous bone, rupture of the tympanum, subdural hemorrhage at the tips of both frontal lobes, with laceration of brain at the frontal tips. General cardiovascular disease was present. The patient should have been decompressed when the blood pressure rose to 170, in the presence of mild papillo-edema, rising blood pressure and bloody cerebrospinal fluid. The relief of the increased intracranial pressure according to the necropsy findings offered a fair prospect of recovery.

*Compound Fractures.*—I have been impressed with the large number of apparently slight compound fractures which terminate fatally, death resulting from a subsequent infection of the meninges long after the first slight symptoms of cerebral trauma have passed, the sepsis entering by way of a linear fracture communicating with a septic skin wound. In many cases, the fracture is overlooked from failure of routine excision and examination of all scalp wounds, which possibly may be associated with fracture.

CASE 7.—A woman suffered a lacerated wound of the parietal region and a slight wound over the eye. The upper wound was explored and no injury to the bone was found. Both wounds were sutured. Eleven days later, the patient became irrational. Exophthalmus developed from pus behind the eyeball. The third roentgenogram revealed extensive linear fracture of the frontal bone, reaching the roof of the orbit. The whole area was bathed in pus. Death occurred seven days later.

*Necropsy.*—Meningitis was found around the site of the fracture.

CASE 8.—A child fell from a window sustaining a slight wound above the eye. There were no cerebral symptoms. The fourth day after admission, the temperature was high. The roentgen ray revealed a linear fracture of the vault. At operation an enormous quantity of pus was evacuated from under the temporal muscle. A long linear fracture was discovered through which at one place the dura protruded. On removal of bone, herniation of the cerebral tissue through the tear in the dura occurred. The abscess of the brain was evacuated. The patient made an uneventful recovery.

*Primary Excision.*—In every case of possible fracture of the skull, all wounds around the scalp should be routinely excised, and the incision extended in whatever direction necessary so that the skin flaps may be pulled apart and the bone exposed. This should be the routine in every hospital service.

If a fracture is not found, the wound, which primarily was infected, having been excised, can be treated as a primary aseptic wound and closed. To allow of complete closure, however, the excision must be complete and performed within six hours of the time of its infliction, as bacteria do not multiply within the tissue for at least six hours. If, during excision, a fracture is seen, it can then be decided what type of operation is necessary.

**CASE 9.**—A man was struck on the head by a heavy hammer falling from a height, causing a compound depressed fracture in the frontal region. On admission, within an hour after the accident, the patient was in good condition and mentally clear.

*Operation.*—Extensive incision of the skin and depressed area of bone was made. A large tear was found in dura, also a slight subdural hemorrhage. Lumbar puncture allowed of tight closure of the dura without herniation, secondary edema not having developed. There was tight closure of the skin wound; a stab wound was made away from the defect to allow for drainage. The following day the patient declared he was well and requested to be transferred to his home.

#### CONCLUSIONS

The principles underlying treatment of fractures of the skull should be: repeated routine recording of the blood pressure, a rising blood pressure or a disproportionately increasing pulse pressure calling for immediate operation; routine examination of the eyes, the development of papillo-edema not accounted for by a vascular lesion calling for operation; immediate lumbar puncture to decide whether there is a hemorrhage within the dura or not, presence of blood in the cerebrospinal fluid making fracture probable but not calling for operation; routine neurologic examination in all cases of suspected fracture.

All wounds of the scalp should be excised, the area of excision being extended to allow of investigation of the bone directly under and in the immediate vicinity of the wound. In the presence of a linear fracture the area should be excised and it should be converted into a simple fracture with primary closure.

#### CHART OF

#### CLINICAL CLASSIFICATION AND TREATMENT OF FRACTURES OF THE SKULL

A. Simple fracture of the skull may be divided into:

- |                   |  |
|-------------------|--|
| (1) Simple linear | (a) without symptoms. Treatment; prolonged rest. |
|-------------------|--|



- (b) with symptoms of compressions. Treatment; operation for relief of compression by (1) removal of extradural or intradural clot with control of hemorrhage by ligation or obliteration; (2) decompression, and (3) lumbar or ventricular puncture.
- (2) Simple depressed (c) with or without cerebral symptoms. Treatment; operation for elevation or removal of depression with or without repair of dura; relief of compression.

B. Compound fractures may be divided into

- (3) Compound linear (d) without cerebral symptoms. Treatment: operation for immediate conversion of compound into simple by excision.
- (e) with symptoms of compression. Treatment: operation for immediate conversion of compound into simple by excision of skin and bone; relief of compression.
- (4) Compound depressed (f) with or without cerebral symptoms. Treatment: operation for conversion of compound into simple fracture by excision, elevation or removal of depression, relief of compression, control of hemorrhage, repair of dura, closure of defect, drainage when necessary by stab wound away from defect.

## GUIDE FOR DETAILED NEUROLOGIC EXAMINATION

The guide is designed to enable hospital interns or trained attendants, without special training in neurology, to conduct a detailed examination by eliciting and recording the details of all objective and subjective symptoms.

The examination is divided into: I. General Neurologic symptoms. II. General Neurologic Examination. III. Cerebral Localization. IV. Examination of Cranial Nerves.

Suggested terms, with possible interpretations, and methods of testing, as well as the normal reactions, are placed in brackets. An asterisk (\*) in the margin indicates examination for unconscious patients. The general sections are indexed by roman numerals, the chief symptoms or manifestations by capital letters, and the individual details by alternate letters and numbers.

### DIRECTION FOR USING GUIDE

The examination begins under the heading General Symptoms.

At the completion of the examination all outstanding symptoms and abnormal findings are recorded on the record sheet, followed by the index numbers and letters according to the guide, enabling a ready reference to the exact location of each detail. Example: "Papillo-edema, IV, B—1." When a general symptom has a direct bearing on the localization it should be cross-indexed. Example: "Dizziness, I. D. and IV, F—2d."

## GUIDE FOR NEUROLOGIC EXAMINATION

(Record Sheet to Be Followed by House Surgeon)

Full Name.....

Address .....

Hospital No.....

*Résumé of History**Résumé of Outstanding Symptoms**Résumé of Abnormal Neurologic Findings*.....  
Signature of House Surgeon

Date .....

## I. GENERAL SYMPTOMS

- (A) Headache? severity ("mild," "intense," "bursting," "throbbing," "lacerating");  
location (frontal, temporal, "behind the eyes," pituitary, occipital, vertex);  
in attacks or constant;  
initial appearance (date).
- (B) Pain? situation (nose, eyes, ears, arms, legs, etc.);  
duration;  
initial appearance;  
in attacks or constant.
- \* (C) Vomiting? frequency;  
type (projectile or regurgitant);  
initial appearance.
- (D) Dizziness? in attacks or constant;  
degree (transient giddiness, swaying, falling);  
duration;  
initial appearance;  
description of (if objects appear to patient to move);  
duration (momentary or continued).
- \* (E) Convulsions? general or localized;  
part involved.  
associated with unconsciousness?  
preceded by aura? (description of aura: visual, flashes of light, objects seen; auditory, tones or music heard).  
during attack: head to right, to left;  
eyes to right, to left;  
arms to right, to left;  
legs to right, to left.

- \* (F) Stupor?      initial appearance;  
                         in attacks?
- (G) Numbness?    situation;  
                         in attacks;  
                         initial appearance.
- (H) Tingling?     situation;  
                         in attacks;  
                         initial appearance.

## II. GENERAL EXAMINATION

- \* (A) Head:
  1. Wounds, description of.
  2. Bleeding from ear: right,      left.
  3. Bleeding from nose: right,    left.
  4. Scars: description of.
- \* (B) Extremities:
  1. Paralysis of arm? right,      left.
  2. Paralysis of leg? right,      left.
  3. Anesthesia of arm? right,    left.
  4. Anesthesia of leg? right,    left.
- \* (C) Reflexes:
  1. Superficial:
    - (a) epigastric;
    - (b) abdominal;
    - (c) cremasteric.
  2. Deep:
    - (a) knee;
    - (b) ankle;
    - (c) Babinsky;
    - (d) Kernig.
  3. Sphincters:
    - (a) loss of bladder control?
    - (b) loss of bowel control?
  4. Vasomotor:
    - (a) abnormal flushing?
    - (b) abnormal sweating?

## III. CEREBRAL LOCALIZATION

- (A) Frontal Lobe:
  - 1 Memory for:
    - (a) names (father's name; street where lives);
    - (b) events.
  2. Orientation.
  3. Affections.
  4. Aphasia:
    - (a) for names or other parts of speech;
    - (b) ability to repeat sentence after examiner.
- (B) Temporal Lobe:
  1. Aphasia:
    - (a) ability to recognize objects and state use, but inability to name ("knife," "key");
    - (b) ability to recognize proper name and ability to repeat name.

2. Uncinate gyrus symptoms:
  - (a) hallucinations of smell;
  - (b) hallucinations of hearing
3. Hemianopsia:
  - (a) right-sided?      left-sided?
  - (b) for form;
  - (c) for colors.
4. Dreamy state?

## (C) Parietal Lobe:

1. Sensory symptoms:
  - (a) paresthesia (touch, pain, temperature);
  - (b) anesthesia;
  - (c) astereognosis;
  - (d) muscle sense.
2. Motor symptoms:
  - (a) paralysis: where, duration;
  - (b) paresis: where, duration;
  - (c) convulsive seizures (Sec. I-E), part involved, consciousness lost?

## (D) Occipital Lobe:

1. Hemianopsia: right-sided?      left-sided?
2. Visual hallucination: right-sided?      left-sided?

## (E) Cerebellum:

1. Dizziness;
2. Nystagmus;
3. Romberg;
4. Disturbances of gait;
5. Ataxia;
6. Adiadokokinesis.

## IV. CRANIAL NERVES

## (A) First ("olfactory"; special sense):

1. Smell (perfumery): right nostril?      left nostril?

## (B) Second ("ophthalmic," special sense):

1. Fundus examination;
2. Vision: right eye?      left eye?

## \* (C) Third, Fourth and Sixth (ocular movements):

1. Pupils:
  - (a) equal;
  - (b) contracted;
  - (c) dilated;
  - (d) react to light;
  - (e) react to accommodation.
2. External ocular movements:
  - (a) diplopia: convergent? right,      left; divergent? right      left?
  - (b) spontaneous nystagmus to right?      to left?
  - (c) conjugate deviation to right?      to left?

## (D) Fifth ("Trifacial," Sensory and Motor):

## 1. Sensory portion:

- (a) anesthesia of { supra-orbital \* (cornea)  
 (b) neuralgia of { infra-orbital  
                           inferior dental  
 (c) taste in anterior two thirds of tongue: (sugar, salt).

## 2. Motor portion:

- (a) buccinator;  
 (b) masseter.

## 3. Vasomotor portion (herpes of brow; of lip).

## \* (E) Seventh (Facial, Motor, Sensory):

## \* 1. Motor Portion:

- (a) Paralysis or paresis: right? left?

Part involved:

- Brow?  
 Lower eyelid?  
 Mouth?  
 Cheek?  
 Palate?

## 2. Sensory portion (taste in anterior two thirds of tongue):

## 3. Vasomotor:

Herpes of ear?

## (F) Eighth ("Auditory" and "Vestibular"; Special Senses):

## 1. Auditory portion:

- (a) Deafness: right ear? left ear?

Hearing { watch  
           whisper right ear? left ear?  
           voice  
                           (normal or otherwise)

- (b) Tinnitus? (special auditory tests to be conducted by specialist)

(a) Tuning fork;

(b) Weber referred to: right, left;

(c) Bone conduction:

Duration of? (seconds) right, left.

\*

## 2. Vestibular portion:

\*

(a) Spontaneous nystagmus;

(b) Spontaneous vertigo;

(c) Spontaneous pointing deviation (downward from shoulder),  
 right arm, left arm.

(d) RÉSUMÉ OF INDUCED VESTIBULAR REACTIONS

(To be filled in by expert after special vestibular tests have  
 been conducted)

## 1. From turning to right:

Nystagmus;

Past pointing: right arm, left arm;

Falling.

## 2. From turning to left:

Nystagmus;

Vertigo;

Past pointing: right arm, left arm;

Falling.

3. From douching right ear:
  - Nystagmus;
  - Vertigo;
  - Past pointing: right arm,      left arm;
4. From douching left ear:
  - Nystagmus;
  - Vertigo;
  - Past pointing: right arm,      left arm;

SPECIAL VESTIBULAR TESTS (To be conducted by expert)

1. Turning to right (reactions induced by turning to right, head forward 30 degrees):
  - (a) Induced nystagmus (normal, horizontal to left)
    1. amplitude
    2. duration (normal, 26 sec.)
    3. direction (normal, horizontal to left);
  - (b) Induced vertigo (normal, to left);
  - (c) Induced past pointing
    - (shoulder from above, normal, to right);
    - Right arm to—
    - Left arm to—
  - (d) Supplementary:
    - Head forward: falling (normal, to right)
2. Turning to left (turning to left, head 30 degrees forward):
  - (a) Induced nystagmus:
    - 1 amplitude;
    2. duration (normal; 26 sec.);
    3. direction (normal; horizontal to right).
  - (b) Induced vertigo (normal; to right);
  - (c) Induced past pointing
    - (shoulder from above, normal, to left);
    - Right arm to—
    - Left arm to—
  - (d) Supplementary:
    - Head forward: falling (normal, to left).
3. Caloric right (reactions induced by douching right ear with cold water, head forward 30 degrees):
  - (a) Induced nystagmus (normal; rotary to left).
    1. amplitude;
    2. duration;
    3. direction.
  - (b) Induced vertigo (normal, to left);
  - (c) Past pointing (shoulder from above, normal, to right);
    - Right arm to—
    - Left arm to—
  - (d) Supplementary:
    1. Head back to 60 degrees:
      - (a) nystagmus (normal; horizontal to left);
      - (b) past pointing (normal; to right);
        - Right arm to—
        - Left arm to—

2. Caloric right (reactions induced by douching right ear with cold water, head forward 30 degrees):

(a) Induced nystagmus (normal, rotary to left):

1. amplitude;
2. duration;
3. direction.

(b) Induced vertigo (normal, to left);

(c) Past pointing (shoulder from above, normal, to right);

Right arm to—

Left arm to—

(d) Supplementary:

1. Head back 60 degrees:

(a) nystagmus (normal, horizontal to left);

(b) past pointing (normal, to right);

Right arm to—

Left arm to—

2. Caloric left (reactions induced by douching left ear, head forward 30 degrees):

(a) Induced nystagmus (normal, rotary to right):

1. amplitude;
2. duration;
3. direction.

(b) Induced vertigo (normal, to right);

(c) Past pointing (shoulder from above, normal, to left);

Right arm to—

Left arm to—

(d) Supplementary:

1. Head back 60 degrees:

(a) nystagmus (normal, horizontal, to right);

(b) past pointing (normal, to left);

Right arm to—

Left arm to—

\* (G) Ninth ("glossopharyngeal," special sense, sensory motor);

Taste;

\*

Swallowing.

.(H) Tenth ("pneumogastric," motor and sensory);

Hoarseness;

\*

Rapidity of heart.

(I) Eleventh ("spinal accessory," motor);

Trapezius muscle;

Sternocleidomastoid;

Shoulder dropping.

(J) Twelfth ("hypoglossal," motor);

How is tongue protruded?

# CHOLECYSTITIS

## ETIOLOGY, DIAGNOSIS AND TREATMENT \*

ROSCOE R. GRAHAM, M.B. (TOR.)

TORONTO, CANADA

The remarks which I shall make on this subject are based on the analysis of the histories of 350 gallbladder cases, which have recently been reviewed. Rather than give a statistical study involving percentages, which are often misleading, I propose to present the fundamental principles which have been elucidated. The application of these to pathologic conditions of the biliary tract I feel has aided in more accurate and, what is more important, earlier diagnoses, resulting in more rational treatment, with better end-results.

### ETIOLOGY

In order to form our own opinions regarding this phase, all gallbladders and, when possible, all appendixes removed at operation were subjected to routine culture between July, 1916, and July, 1920. Recently we have not been content with aerobic cultures solely, but have used partial anaerobic culture methods. In the latter, the tissue has been macerated by grinding in a mortar with fine sand, and then planted in the depths of agar medium. Miss Wessels, working in the department of bacteriology under the supervision of Detweiler, has recently most carefully carried out this part of our investigation. In the earlier cases, it was possible to isolate a streptococcus from the wall of the gallbladder in a certain number of instances. In many of these, cultures of an identical strain were also taken from the wall of the appendix; the majority of the cases, however, were sterile, or grew *Bacillus coli*, which we considered was incidental rather than pathogenic. The number of instances of associated streptococci in the appendix and gallbladder led us to believe that organisms from a distant focus were the source of the trouble. The question then arose: Did the gallbladder and appendix become involved simultaneously, or was the appendix the initial lesion, with the gallbladder secondarily infected through the portal circulation? The latter we believe to be most common.

Between July, 1919, and February, 1920, however, our results as far as cultures are concerned have given us grave cause for thought. This series representing fifty-two cases gave cultures in eight instances;

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\* From the surgical clinic of Dr. F. N. G. Starr.



one pure colon; one colon and streptococcus; two *Staphylococcus aureus*; one diphtheroid; three pure streptococci; all the rest being sterile. One interesting feature in this series was again called to mind, namely, that as yet we have not recovered *Staphylococcus aureus* on culture in any instance in which the patient did not give a clinical history of mucous colitis in varying degrees of severity. That we have not removed normal gallbladders is proved by the subsequent clinical history and the microscopic examination, which is made in every instance. The microscopic changes which have been found are those characteristic of reaction to injury and were present in all gradations.

Thus, we are forced to believe that the symptoms resulting from a diseased gallbladder for which patients seek relief are not due to the immediate presence of organisms in the lumen or wall of the gallbladder. The corollary, then, is that they are the result of damage to the tract which remains after the infecting organism has been effectively dealt with. That the infecting organism is killed one cannot say, but, if present, it is so susceptible to changes of environment that only rarely can one recover it by culture.

We are quite in accord with Naumyn's hypothesis that changes seen in the biliary tract are the result of the reaction to bacterial injury. Graham<sup>1</sup> recently, however, has thrown some light on the significance of colon bacilli found with cultures. He believes that they are not incidental or natural habitants of the biliary tract, but are pathogenic factors, the latter belief being based on the fact that the serum from such individuals agglutinates the strain of colon isolated in the particular culture. In one case, agglutination occurred with a serum dilution of 1 in 80. That this phenomenon is sufficient evidence on which to base a conclusion is open to doubt.

#### DIAGNOSIS

The diagnosis of the gallbladder disease presents difficulties of varying degrees, dependent upon the damage which has remained in the biliary system. In order that we may classify the various groups of biliary symptoms, the scheme<sup>2</sup> formerly suggested seems adequate: (1) the type in which all the symptoms are gastric with nothing definite to direct one's attention to the right upper abdomen. Here the diagnosis has to be made very largely by a process of elimination. (2) That in which symptoms are referred to the right upper abdomen. These are the result of subacute inflammatory changes, or to the movement of calculi, or both. (3) Acute emergencies—such as empyema, gangrene and common duct obstruction, not forgetting malignancy.

1. Graham, E. A.: Hepatitis, Surg., Gynec. & Obst. **26**:521 (May) 1918.

2. Starr and Graham: Cholecystitis, Ann. Surg. **68**:188 (Aug.) 1918.

The first two types present the greatest difficulty. The reason for this is to a large extent due to the fact that for such a long time gall-bladder lesions meant gallstones. Until we can forget that such foreign bodies form, or at least until we consider them only as an incident rather than as essential, there is slight hope for improvement in the surgical therapy of biliary lesions. To wait for jaundice and colic in order to make a diagnosis is like waiting for metastasis before diagnosing a malignant new growth; also nausea and vomiting are no more essential for diagnosis than is jaundice. The diversity of symptoms relieved by surgical intervention in diseases of the biliary tract is too widespread to be explained by contiguity inflammation, originating in the gallbladder and ducts. Moreover, such an explanation can gain no support from the gross pathology observed during operative procedures. The fact remains, however, that patients are relieved of widely divergent and varied symptoms by dealing surgically with the local pathologic condition of the biliary tract.

In a recent article, Goldie<sup>3</sup> has laid stress on the proper interpretation of gastro-intestinal symptoms, pointing out clearly that in the large percentage of instances in which the patient seeks relief from "stomach trouble" the etiologic factor is found in other portions of the gastro-intestinal tract, with no gross lesion of the stomach. It is in the proper interpretation of such symptoms as fulness in the epigastrium, belching, loss of appetite, etc., that we can hope for most in the accurate diagnosis of noncalculous cholecystitis.

An important fact to remember is that the gastro-intestinal tract has a double nerve supply: first, the vagus and the nervus irrigens from the bulbar and sacral segments; and secondly, the thoracolumbar autonomic system, or the sympathetic nervous system of the old nomenclature. The thoracolumbar autonomic system controls the sphincter system of the gastro-intestinal tract; that is, it has control of the pylorus and ileocecal sphincters, and possibly the sphincter of Oddi, at the entrance of the ampulla of Vater into the duodenum.

The association between the ileocecal sphincter and the pylorus was proved by Gaskell<sup>4</sup> more than thirty years previous to its clinical application, in the treatment of so-called appendicular dyspepsia, by the removal of a chronically diseased appendix. This association has now come to be so well recognized clinically that it needs only to be mentioned. A confirmation of this close association was recently reported,<sup>5</sup>

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3. Goldie, W.: Interpretation of Gastro-Intestinal Symptoms, *Canad. M. A. J.* **11**:5 (Jan.) 1921.

4. Gaskell, W. H.: *The Involuntary Nervous System*, New York, Longmans, Green & Co., 1910.

5. Ileocecal Sphincter, Editorial, *Brit. M. J.*, Aug. 19, 1919.

in which as a result of a cecostomy for dysentery, the ileocecal valve became visible in the wound; thus the contraction of the sphincter could be visualized and palpated, and the close relationship between its contraction and gastric intake was demonstrated. Is it then inconceivable to believe that the same relationship exists between ileocecal valve, pylorus and sphincter of Oddi, which controls the outflow of the common bile duct? Meltzer's<sup>6</sup> opinion would seem to substantiate this.

Thus, we see that in addition to the so-called "appendicular dyspepsias," we must add the "biliary dyspepsias," and be on our guard lest gastric symptoms mask the pathologic condition of the biliary tract. We are forced to believe that in nearly 90 per cent. of instances in which the symptoms are gastric, the pathologic condition is remote from the stomach, and the clinical picture the result of reflex irritation arising from other portions of the gastro-intestinal tract. Such reflex irritation is exemplified by pylorospasm. In one instance, during a gastro-intestinal roentgen-ray examination with an opaque meal, a gastric spasm was noted and examined at intervals for a period of half an hour, and a series of plates were made. This spasm was so constant and unchanged that a roentgenographic diagnosis of hour-glass stomach was made. At operation, however, the stomach was found to be normal, and the patient was relieved of all symptoms after the pathologic condition of the biliary tract had been dealt with and the appendix had been removed. Pylorospasm is very real, and can temporarily give symptoms which would lead even careful observers to diagnose a primary stomach lesion. Often during the course of operations one can visualize spasm in the pyloric region of the stomach, occasionally of the ring type, but most often localized areas become contracted, giving a gross appearance not unlike that which would develop from the application of a hot iron to the serous surface. Such areas are blanched, raised above the serous surface of the stomach, feel firm to the touch; in fact they are very like the base of an ulcer, and could easily be mistaken for such unless one were experienced in their gross appearance, or waited for from twenty to thirty seconds and watched them disappear, leaving a normal stomach area. Indeed, it has been our misfortune to have to deal with cases in which, as the result of an erroneous interpretation of these areas, a gastro-enterostomy had been performed with, of course, no relief to the patient.

A further interesting observation has been made during operation on patients suffering from pylorospasm due to cholecystitis. An area of the stomach, from  $2\frac{1}{2}$  to 3 inches proximal to the pylorus, appeared erythematous, not unlike the appearance of a first degree burn. The

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6. Meltzer, S. J.: The Disturbance of the Law of Contrary Innervation as a Pathogenetic Factor in Diseases of Bile Ducts and Gallbladder, *Am. J. M. Sc.* **153**:469 (April) 1917.

superficial vessels were engorged, tortuous and dilated; the pyloric vein varicose, and the vessels in the gastrohepatic omentum markedly varicose. May this be a factor in the production of a gastric or duodenal ulcer, which is not infrequently found in association with a chronically diseased gallbladder?

One realizes also that nearly all abdominal pain, crampy or colicky in character, is the result of muscular spasm in, or distention of, a hollow viscus with its own contents, or those of a mildly inflammatory character. Hence a spasm can be initiated by a diseased gallbladder, and give crampy pain of varying degrees of severity. Also a spasm occurring out of time with the normal peristaltic waves could cause increased intragastric pressure and a distention of a segment of the stomach, with the same result. That this is no mere hypothesis is shown by the fact that such occurrences are daily visualized in the roentgen-ray laboratory.

I cannot agree with Stewart and Barker<sup>7</sup> that there is a constant hypermotility in chronic disease of the gallbladder, for we have seen 40 per cent. gastric residue ten hours after a barium meal, and at operation found a normal stomach and duodenum. Thus, it would appear that the essential thing is to differentiate the lesions that will initiate pylorospasm.

The recent tendency has been to rely so much on roentgen-ray diagnosis that it will be considered last. The really important part of the investigation of such a patient is a carefully taken history. One has only seriously to attempt this for a few months to realize how difficult and formidable the task becomes. We are dealing with patients who have a history of gastro-intestinal disturbances extending over many years, and have tried to rise above it for so long that unconsciously they will give misleading answers to inquiries, unless one approaches their disabilities from many angles. An inquiry as to the previous health of such patients will usually reveal a history of gastro-intestinal upsets or bilious attacks beginning when quite young and continuing with remission until seen at consultation.

One can divide the life cycle into various stages: first, the pre-pubescent period; second, puberty; third, from puberty until 25 years of age; fourth, from 25 to 40 years of age; fifth, from 40 years of age till death. In these various stages we have three main factors to consider: physical trauma; mental and physiologic strain, and infections. In the prepubescent period there are the gastro-intestinal upsets due to dietetic errors, and the infections so common in childhood. In the

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7. Stewart, G. D., and Barber, W. H.: *Hypermotility of the Stomach in Gallbladder Disease, Duodenal Ulcer and Appendicitis*, J. A. M. A. **73**:1817 (Dec. 13) 1919.

second period, there are the physiologic phenomena of puberty at a time when with our educational system there is tremendous mental strain. In the third, from puberty till 25 years, there is the greatest freedom from all these stimuli. In the fourth, there are business responsibilities as a mental strain in men, and child-bearing in women. In the fifth, there are the inevitable degenerations coupled with the menopause in females.

In gallbladder disease, it is noted that the periods of exacerbation correspond very accurately with these disturbances, and this fact is strong evidence of such a lesion. In other words, there is a close association between nervous, physical and physiologic strain, and the occurrence of symptoms. One of the important physical factors to consider is, of course, not only the acute infections from which the patient has suffered, but also the possible chronic ones from which he may still be suffering, such as, infected teeth, tonsils, or accessory sinuses.

Goldie <sup>3</sup> has also pointed out the very great importance of noting the time of occurrence of gastric distress, and also of analyzing in detail the various symptoms. He cites appetite as an instance of the necessity for qualifying statements, because in the atonic stomach the appetite is lost, with no distress, whereas in the hypertonic stomach there is loss of appetite with distress. It is common to hear statements made that there is a loss of appetite in chronic gallbladder disease; but if this is pursued further one will find that the appetite is good, but readily satisfied. It is not the loss of appetite which one finds in cases of gastric ulcer, in which the patient has a fear of the consequences of taking food. The gallbladder patient, however, in addition to being satiated by a small volume of food, complains of an indefinite fullness, distress or uncomfortable feeling in the epigastrium about half an hour later, rarely complaining of actual pain. There may be belching of gas, but this will not occur for about half an hour after taking food. This must not be confused with the belching which occurs immediately after a ravenously eaten meal, which is due to the fact that the cardiac sphincter has not yet closed. Whether the patient suffers from belching of gas is dependent upon whether the peristaltic wave is going to force the pylorospasm or the cardiac sphincter. This discrepancy in the contracting of various parts of the stomach is evidenced by clinical symptoms of belching, pyrosis, or actual nausea and vomiting, depending on the degree of muscle tonus.

At this stage of gastro-intestinal metabolism, bile is normally poured into the duodenum. If the biliary lesion has rendered the nervous control of the sphincter hypersensitive, can we not have spasm of the ampulla and of the pylorus occurring at the same time? That the flow of bile is interfered with is borne out by the fact that these patients

volunteer the information that they suffer more discomfort when eating food fried in grease, or that containing an excess of fat. Archibald and Brow<sup>8</sup> and Mann<sup>9</sup> have shown clearly that the sphincter of Oddi is real, and when contracted will withstand a pressure varying from 100 to 500 mms. of water.

Sick headaches or bilious attacks are often the real cause of a patient's appearance in the consulting room. Here one has to rule out headache and nausea of extragastro-intestinal origin. The commonest probably is a refractive error, in which the headache precedes any gastro-intestinal discomfort. This emphasizes the fact that in patients whose headache precedes any abdominal discomfort, the etiologic factor is usually extragastro-intestinal. In chronic appendicitis, we have the nausea, but headache is a rare accompaniment; but both occur subsequent to abdominal distress. In gallbladder disease, there is an epigastric distress previous to the appearance of a headache or nausea. In atonic lesion of the cecum, with incompetency of the ileocecal valve, there is a cyclic occurrence in which the headache is worse in the morning, with the period of greatest well-being between 4 and 6 p. m., which time corresponds to the reemptying of the ileum. If the patient complains of headache and nausea of recent occurrence, with no history dating over a long period, one can reasonably exclude gallbladder disease.

Having thus elicited the subjective history, one proceeds to the objective, by means of physical examination. Babcock<sup>10</sup> has drawn attention to the fact that one must be on the alert to avoid an erroneous diagnosis of a primary cardiac lesion, when a patient presents a cardiac murmur, associated with an enlarged liver and gastric symptoms. One should not lose sight of the fact that the liver and bile ducts may be the seat of the primary pathologic condition. One patient under observation presented extreme arrhythmia, enlarged liver, and jaundice, the whole condition clearing up when the pathologic condition of the biliary tract was dealt with. In this instance there is additional interest, because the source of the infection was apparently from an ischiorectal abscess.

On abdominal palpation one too often elicits nothing but negative information in gallbladder disease. If the gastric distress is due to an appendicular lesion, one can often elicit a tender area in the right iliac

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8. Archibald and Brow: Experimental Production of Pancreatitis in Animals, As Result of Resistance of Common Duct Sphincter, *Surg. Gynec. & Obst.* **28**:529 (June) 1919.

9. Mann, F. C.: A Study of the Tonicity of the Sphincter at Duodenal End of Common Bile Duct, *J. Lab. & Clin. Med.*, **5**:107 (Nov.) 1919.

10. Babcock, R. H.: The Diagnosis of Chronic Cholecystitis Complicating Cardiac Lesions, *J. A. M. A.* **73**:1929 (Dec. 27) 1919.

fossa, with pain referred to the epigastrium; or if due to an atonic cecum, one can roll the full boggy cecum under the fingers. In the noncalculous variety of gallbladder disease, the tenderness under the right costal margin is indefinite, but is found occasionally. When pressure in this area produces pain radiating to the epigastrium, it is fairly good evidence of a biliary lesion. Several deep inspirations following one another in quick succession often produce a tired sensation in the right upper quadrant of the abdomen. Another tender point often noted is just above and to the left of the umbilicus. This has been ascribed by some observers to spasm of the colon, but in view of the constant location of the tender point and the extreme variation in the site of the colon, it seems highly improbable that this is the proper interpretation. It is felt that it is due to pancreatic involvement. In a former communication the close association between pancreatic lesions and gallbladder disease has been emphasized.<sup>11</sup>

However, tenderness along the course of the whole large bowel, together with the presence of mucus in the stools, has been noted so often in connection with biliary disease, that it cannot be regarded as a mere coincidence. In fact, it is felt that biliary lesions are responsible for mucous colitis to such a degree that we have explored the liver and bile ducts on little more than this evidence in a few instances, and have been rewarded by finding pathologic conditions which when dealt with surgically have relieved the patients of their disability. The convalescence in such a clinical condition is nearly always in direct ratio to the amount of mucus present, and the chronicity of the lesion; that is, the more severe the colitis, and the longer its presence, the more prolonged will be the convalescence.

Another important factor in determining the site of the lesion is the alteration of the superficial sensory and motor reflexes. Goldie<sup>3</sup> lays emphasis on this, and states:

There are apparently three sources from which the sensory nerve fibers are derived, all the nerve cells of which remain within the central nervous system, including the posterior root ganglia. First, those fibrils which accompany the original ingrowth; second, those which accompany the blood vessels and are associated with the thoracolumbar autonomic system; third, those derived from the somatic areas, which provide supporting structures to the specialized and fully developed secondary outgrowths of the gastro-intestinal tract.

The primary ingrowths develop from the anterior and posterior appendages, without any intimate relationship with the somatic areas, and join each other in the region of the tenth dorsal somatic area. Before the secondary development takes place, the great growth in length gives rise to an "S"-like curve in the anterior ingrowth, the upper part of which passes to the left in the region of the fifth somatic area, crosses the midline to the right about the seventh to

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11. Starr Clinic, *Canad. M. A. J.*, March, 1921.

eighth dorsal, and recrosses the middle line from right to left in the region of the seventh to eighth dorsal, terminating at this point in the cecum. The stomach develops mainly on the left from the sixth to eighth segments. The outgrowth, which becomes the gallbladder and liver, develops dorsally, and grows out to the right, so that the liver obtains its supporting structures from the eighth to ninth dorsal segments. The gallbladder, less extensive in its growth, develops near the middle line, obtaining its structural support just to the right of the midline of the ninth to tenth somatic areas.

The clinical application of this is that in chronic gallbladder disease one finds that on lightly stroking the abdomen there is increased hypersensitiveness and hypermotility in the right upper quadrant of the abdomen, and also, as pointed out by Ewald, just below the tip of the right scapula. Also one finds tenderness on pressure over the posterior branches of the *right* ninth and tenth intercostal nerves, whereas if the lesion were in the cecum or appendix, there would be hypersensitiveness of the *left* upper abdomen, and tenderness on the posterior branches of the *left* eighth, ninth and tenth intercostal nerve; and if the stomach itself were at fault, it would be tender over the posterior branch of the left sixth and seventh intercostal nerves.

Thus, we see the extreme importance of a careful history, taken with a wide mental perspective, and a careful physical examination based on embryology, if we are to deal effectively with gallbladder disease at a stage when the mortality is very low, rather than waiting for definite localizing signs, when the involvement is such as to give an operative mortality of from 15 to 25 per cent., with a much smaller percentage of complete cures in the survivors.

Having examined a patient with a chronic gastro-intestinal disorder in this manner, one can then refer him to the roentgen-ray laboratory with a provisional clinical diagnosis. The most one can hope for from the roentgen-ray examination of patients suffering from early non-calculous cholecystitis is the exclusion of other pathologic conditions. A roentgen-ray expert can exclude ulcer of the stomach or duodenum, and atony of the cecum with incompetency of the ileocecal valve. Whether one should accept a roentgen-ray diagnosis of chronic appendicitis is doubtful. Chronic appendicitis, as the sole lesion, in the absence of a previous acute attack, is a very rare condition, and a diagnosis that should not be lightly given, if the number of persons one sees with beautiful scars following appendectomy in such cases, but no relief from symptoms, is any criterion. It would thus appear unwise to accept the evidence of retention of barium in an appendix as sufficient evidence in itself to justify a diagnosis of chronic appendicitis.



## COMPLICATIONS

It is not proposed to enumerate the complications which may occur for they are well known to everyone, but to state that all complications have been encountered in this series. Some are worthy of note. Two patients with empyema had an associated acute appendicitis in which both organs were covered with fibrin. Such an occurrence serves to put one on guard during operations for these lesions. Two instances of focal necrosis in the liver have been encountered, and we can give no satisfactory explanation. In both cases, the liver presented white areas which looked not unlike localized tubercles in one instance, and in the other, closely resembled new growth. In each case, however, microscopic examination proved that they were the result of the inflammatory process. Both patients have replied to the questionnaire and are at present perfectly well.

One often hears it stated that rupture of a gangrenous gallbladder is of common occurrence. In our series it has occurred only twice. Neither case gave the grave clinical picture that one would expect from such a serious lesion.

Pancreatitis has been encountered in all stages from a mild fibrosis to the acute hemorrhagic variety. Of the latter type, one case occurred recently, and while stones were present in the gallbladder, the common duct was patent. Can spasm of the ampulla explain the regurgitation of bile into the pancreatic duct with the resultant lesion? Archibald<sup>8</sup> has shown that this is very likely. Professor Mackenzie<sup>12</sup> suggests as a further explanation that there is a stenosis at the ampulla due to long continued inflammation and fibroblastic proliferation, causing some bile to be constantly forced into the pancreas.

Lastly, as a complication let us not forget the possibility of carcinoma. Stones were present in every case of carcinoma encountered. We know the disastrous clinical results of such a lesion. This in itself should be a great stimulus to an attempted early diagnosis previous to the formation of calculi.

## TREATMENT

That a diseased gallbladder will eventually require surgical treatment for relief of symptoms is now fairly well established. That the end-results of surgical intervention show a higher percentage of cures than formerly is a fact. That still better results can be obtained is not without the realm of possibilities. Our ambition in treatment is thus to find the guiding principles for our operative procedure which will give the maximum percentage of cures.

The greatest principle underlying such an idea is to realize that we must enlarge our mental horizon and visual field regarding gallbladder

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12. Mackenzie, J.: Personal communication.

disease and the pathologic condition associated with it. One can but rarely diagnose with certainty all existing pathologic conditions prior to operation. Unless one appreciates the dissemination of the lesions which may be present, one will many times fail at operation to add to the preoperative findings. Hence adequate and appropriate exposure is absolutely essential not only from the standpoint of safety, but to enable one to grasp in panorama the whole pathologic condition.

When the abdomen is opened, a definite routine of investigation is followed before deciding upon the particular procedure necessary in any case. In other words, we adapt the operation to the pathologic condition; we do not make the pathologic condition suit a stereotyped operation.

The plan of investigation is this: The cecum is delivered into the wound, and its tonicity is noted. The terminal ileum is examined for kinking. The presence or absence of pericecal or pericolic bands is noted. The glands of the mesentery are palpated, and here one is often rewarded by finding calcareous areas, tombstones of a previous tuberculous lesion which may be invaluable in future treatment and prognosis. The appendix is removed; the competency or incompetency of the ileocecal valve is noted. Attention is next directed to the stomach and duodenum for the presence of ulcer or spasm. The pancreas is then examined by palpation and if it suggests a pathologic condition, can often be visualized through the anterior layer of the lesser sac above the stomach. Having determined the presence or absence of a pathologic condition in these areas, the gallbladder and ducts are examined. To determine at operation whether a gallbladder is pathologic or not in the early stage of the disease requires careful attention to detail and accurate observation.

It is now well established that a gallbladder which in the gross shows little evidence of a pathologic condition can cause a diversity of clinical symptoms, which are relieved by its removal. Recently, we have observed that the liver presents gross pathology in a considerable number of cases. The changes are principally two: First, in the instances of a calculous cholecystitis, the liver is larger and more friable; secondly, areas of localized scarring or cirrhosis either in the region of the gallbladder or occasionally scattered diffusely throughout the liver. As to the nature and pathogenesis of this condition, I cannot state definitely; but in the few cases in which we have excised areas of liver and examined the tissue microscopically, we have found evidence of an inflammatory reaction around the peripheral bile capillaries. I feel that this is the result of a pathologic condition of the biliary tract and will often give a clue to the localization of the lesion in an otherwise

obscure intra-abdominal condition. The ducts and their associated lymph glands are palpated in their entirety and as accurately as possible any abnormality is made out.

As far as pericholecystic adhesions are concerned, I believe that with the exception of the obvious instances in which they result from contiguous inflammatory processes, they are an indication of a pre-existing inflammatory process, originating in the wall of the gallbladder. That such adhesions can cause definite symptoms I do not doubt. In 1,000 cases reported by Smithies,<sup>13</sup> only 4.2 per cent. gave no symptoms of gallbladder disease. That the mere separating of these adhesions will secure the desired result, I do not believe. In a later communication, it is hoped to prove that abdominal adhesions are the result and not the cause of intra-abdominal pathologic conditions, the latter being responsible for the clinical symptoms, except in the few instances in which they cause intestinal obstruction.

As to the question of drainage versus excision of the gallbladder, I believe that the condition of the patient is the determining factor, except in case of irreparable common duct obstruction, in which it is used in performing cholecystenterostomy. One reason for this stand is that I agree with Judd<sup>14</sup> that the common duct dilates after cholecystectomy. Thus the sphincter of Oddi is no longer effective, and continuous drainage of bile into the duodenum is allowed, and thus we remove the source of our reflex irritation. This is borne out by Meltzer.<sup>6</sup>

The real question we have to decide is: Shall we or shall we not drain the biliary tract? There are four instances in which I feel drainage of the biliary tract is demanded in addition to the removal of the gallbladder: (1) in cases of subacute pancreatitis with swelling of the pancreas; (2) in cases in which the gallbladder is filled with fine sand; (3) in those in which the patients' condition permits a cholecystectomy but in which the patients are undernourished and anemic, the result of a long illness, and (4) in cases of long-continued noncalculous jaundice of biliary origin.

To put a tube in the gallbladder I feel is not in the least efficacious in draining the biliary tract. The average volume of bile collected from a cholecystostomy is but a small percentage of the volume secreted.

Direct drainage of the common duct is not without its disadvantages. In order to do this, the duct has to be incised and it must heal by fibroblastic proliferation which may cause a stenosis, if not obstruction.

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13. Smithies, Frank: Pericholecystitic Adhesions, *J. A. M. A.* **71**:1804 (Nov. 30) 1918.

14. Judd, E. S.: The Effect of Removal of the Gallbladder, *Surg., Gynec. & Obst.* **24**:437 (April) 1917.

I have chosen to pass a catheter through the stump of the cystic duct and thence into the duodenum. Such a procedure has several advantages. In the first place, the entrance is gained to the common duct with no trauma to that structure; the catheter passing through the sphincter of Oddi at the ampulla causes the sphincter to relax and the bile drains continuously into the duodenum, around the catheter; thus, only the small volume which drains through the cystic duct is lost to the patient's metabolism. This volume is drained to the outside by a second tube which is placed close to the stump of the cystic duct, the general peritoneal cavity being walled off by means of strip gauze.

Still other advantages are the therapeutic possibilities of a tube being in direct communication with the duodenum. This has recently been pointed out by McWhorter.<sup>15</sup> The use of this tube in conveying nourishment directly into the duodenum was first described by F. N. G. Starr<sup>16</sup> in 1899. We put in now varying strengths of glucose for nourishment, and if the requirement is simply to supplement the body fluids, the normal saline can be used. This is particularly valuable in the type of case in which the patient is undernourished and suffering from a secondary anemia. When the patient has reached the stage in which cathartics are required, they too can be given by means of the tube. Since adopting this practice in emaciated patients, the post-operative convalescence has been much less anxious, and the patients have recovered much more rapidly. As to the length of time that the tube should be left in situ, I believe that with the exception of the pancreatic cases the condition of the patient is the index of when it should be removed. In the former, I believe that it should be left in situ for at least two, if not several, weeks, depending upon the degree of pancreatic involvement.

Another factor which I believe is of great importance is the prevention of postoperative adhesions. This to a large degree can be accomplished by the restoration of the peritoneal continuity of the under surface of the liver. A running suture of catgut is used to unite the reflected margins of the peritoneal coat of the gallbladder. In some instances, this is not possible, particularly if there has been a large gallbladder or an acute process, with a resulting friable liver tissue. In such a condition, a free omental graft is laid over the fissure and fastened by interrupted catgut sutures. This in addition is very effective in controlling the oozing which is often troublesome in this type of case.

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15. McWhorter, G. L.: *The Common Bile Duct Sphincter*, Surg., Gynec. & Obst. **32**:124 (Feb.) 1921.

16. Starr: *Canad. J. M. & S.*, 1899.

As to the advisability of always using drainage in these cases, I believe that it is safer. Why it should be necessary to drain a simple, straightforward cystectomy when we can feel practically certain that no bile will leak from the cystic duct, I cannot explain. However, in cases in which no drain was left, I felt that the postoperative convalescence was not so smooth.

#### PROGNOSIS AND RESULTS

The result of surgical interference in biliary lesions is disappointing to a certain percentage of the profession. This conclusion to a large extent is due to the fact that biliary colic was the signal for operation in the past, and surgery could immediately relieve this. Today we are attempting earlier treatment and at a time in the course of the disease when surgery can deal only with the exciting cause, having to depend on nature and the lapse of time to repair the damage done to the nervous mechanism and thus abolish the reflex disturbances. This improvement may in a fair percentage of cases be spectacular; but in the type of case in which there is a definite relationship between the attack and mental and nervous exhaustion, the improvement will be definite but gradual over a period of from ten to twelve months.

In our experience, the stone cases have a certain chance of complete cure from drainage, but in replies to our questionnaires we find that in the earlier acalculous cholecystitis cases in which drainage was used there is a persistence of a certain degree of the gastric distress.

#### CONCLUSIONS

1. The primary etiologic factor in gallbladder disease is bacterial infection. If, however, the patient seeks relief at this time, it will be most often because of an acute inflammatory lesion of the gallbladder.

2. The chronically diseased gallbladders produce symptoms of a reflex nature as a result of tissue changes, resulting from the presence of an avirulent organism.

3. The vast majority of gallbladders removed for reflex symptoms are sterile on culture.

4. The diagnosis of a diseased gallbladder rests largely on a well-taken history, keeping in mind the innervation from an embryologic standpoint, and thus making possible a correct interpretation of clinical symptoms.

5. The increased efficiency of gallbladder surgery lies in the avoidance of stereotyped operations, the recognition of the whole pathologic condition present, and then suitably dealing with it.

# FURTHER OBSERVATIONS ON THE CLINICAL VALUE OF CERTAIN BACTERIOSTATIC TRIPHENYL- METHANE DERIVATIVES

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SAN FRANCISCO

The specificity of the action of certain drugs against particular infections has been recognized for a great many years. Perhaps one of the first drugs to be so used was quinin, which was employed in its original state in the treatment of malaria, between the years 1630 and 1640. In 1638, it is said to have proved efficacious in the case of the Countess of Chinchon, whose name was later applied to the bark which the Spanish brought from South America.

After an exhaustive investigation of certain arsenic compounds, Ehrlich<sup>1</sup> arrived at the formula of arsphenamin in the treatment of syphilis. In this case, the toxophore radical of arsphenamin has a greater affinity for the parasite than it has for the body cells of the animal host.

These two classical cases may be cited as opening the way to further knowledge of specific chemotherapy.

## CHEMISTRY OF DYESTUFFS

I shall consider first the chemistry of certain dyestuffs, whose action will be discussed in more detail later.

Triphenylmethane,  $\text{CH}(\text{C}_6\text{H}_5)_3$ , is a crystalline substance and serves as the base for many of the dyes. There are three stages in the formation of the dye: (1) the formation of a (colorless) leukobase; (2) the formation of a (colorless) color base, and (3) the formation of a dye.

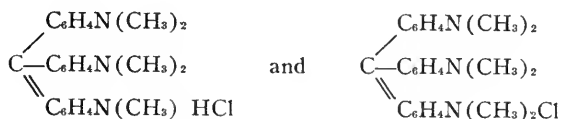
Many dyes exist as salts, but on account of their basic reaction they readily dissolve in acid solutions, losing their characteristic color which reappears when an excess of alkali is added to neutralize the acid.

Pararosanilin and rosanilin may have several of the hydrogen atoms of the amino groups replaced by alkyl radicals. The simplest of these dyes are yellow in color, and with the increase in molecular weight, or, in other words, with the increase in the number of alkyl or phenyl groups, the color is changed through orange and red to violet and blue. These substances are crystalline in form, and a great many of them are insoluble in water but highly soluble in alcohol.

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1. Ehrlich: Abhandlungen über Salvarsan 1-3.

It is possible to create certain intensities in color by the addition of certain radicals to the general formula. The addition of methyl groups increases the violet color in direct proportion to the number of methyl groups added. Thus the double salt, pentamethylpararosanilin and hexamethylpararosanilin or "methyl violet" is formed, whose structural formula is a mixture of the following:



By the replacement of one hydrogen atom of each amino group of rosanilin by a phenyl radical, a blue dye may be formed; thus we may make "anilin blue," triphenylrosalin-hydrochlorid. The intensity of the blue color depends here also upon the number of phenyl groups added to the structural formula.

Crystal violet (hexamethyltriaminotriphenylmethane) serves as an excellent example of a phenomenon exhibited by an analogous group of basic substances. When an equivalent amount of alkali is added to any salt of crystal violet, there is no immediate change in the color of the compound. But with the addition of a similar amount of acid, the color base dissolves to form a compound of a different color and not highly water soluble. This color base can, however, be reprecipitated by the addition of an equivalent amount of alkali to the solution, thus bringing back the violet color.

The foregoing will give the reader some idea of the relationship of these compounds to one another and show how the triphenylmethane radical is the fundamental basis of this entire group of compounds.

#### INHIBITORY PROPERTIES OF DYESTUFFS

Many of these substances have long been known to exhibit inhibitory properties upon the growth of certain organisms in culture mediums. Peabody and Pratt<sup>2</sup> used malachite green solution as an enriching agent in the isolation of *B. typhosus*.

Churchman,<sup>3</sup> found that gentian violet in dilutions of 1:100,000 inhibited the growth of certain types of bacteria while other types were

2. Peabody, F. W., and Pratt, J. H.: On the Value of Malachite Green Media in Differentiating Typhoid and Colon Bacilli with the Description of a New Method of Isolating Typhoid Bacilli from Feces, Boston M. & S. J. **158**: 213, 1908.

3. Churchman, J. W.: The Relative Bactericidal Action of Gentian Violet, J. Exper. M. **16**:221, 1912. Churchman, J. W., and Michael, W. H.: The Selective Action of Gentian Violet and Closely Related Bacterial Stains, J. Exper. M. **16**:822, 1912.

not affected by its presence. Those organisms which grew in the presence of gentian violet solution were of the gram-negative type, whereas those which were inhibited belonged to the gram-positive group. Churchman<sup>4</sup> used a diagram to illustrate the effect of gentian violet upon gram-negative and gram-positive organisms. He found that out of 182 strains of gram-positive organisms, only seventeen strains were unaffected, and out of 136 strains of gram-negative organisms, only fifteen were unaffected by the dye.

In an earlier publication, he used the terms "violet-positive" and "violet-negative" for the action of the dye in its inhibition as associated with gram-positive and gram-negative organisms. This nomenclature was objected to on the ground that the selective action of the dye is not at all dependent upon the color of the dye but rather upon some other factor. Consequently, he modified the terms in regard to the use of gentian violet to "gentian-violet-positive" and "gentian-violet-negative" in regard to its selective action upon the growth of bacteria.

Since, however, these terms are only adaptable to the one dye mentioned above, they could hardly be applied to other dyes of the same type. Better terms would be perhaps "triphenylmethane-positive" and "triphenylmethane-negative" in regard to the action of this whole group of chemicals in their selectivity upon the growth of gram-positive and gram-negative organisms.

Crossley<sup>5</sup> also noted that the inhibition of gram-positive organisms by crystal violet took place when other members of the triphenylmethane group were used.

He assumed that there are two factors at work which control the action of the dye: (1) the composition of the dye, and (2) the nature of the organism. He further suggested that there must be certain groupings inherent in the dye which combine with certain "reactive groups" in the structure of the organism, and thus produce bacteriostasis.

This selective action appears to be related in some way to the basic nitrogen, and substitution of methyl grouping for the aminohydrogen groupings causes an increase in bacteriostasis on the part of the compound. He called attention to the value of this feature in the treatment of infections, and suggested that further work be done on allied compounds.

It was Churchman<sup>6</sup> who called attention to the fact that dahlia, parafuchsin, magenta, pararosanilin, rosanilin, crystal violet, methyl

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4. Churchman, J. W.: Gentian Violet in the Treatment of Purulent Arthritis, *J. A. M. A.* **75**:583 (Aug. 28) 1920.

5. Crossley, M. L.: Gentian Violet, Its Selective Bactericidal Action, *J. Am. Chem. Soc.* **41**:2, 2083, 1919.

6. Churchman, J. W.: The Selective Bactericidal Action of Stains Closely Allied to Gentian Violet, *J. Exper. M.* **17**:373 (April) 1913.



violet, all have one thing in common, that is, their selective action upon bacteria, and he assumes that since each compound is a derivative of triphenylmethane, the power of bacteriostasis is inherent in this triphenylmethane radical.

Churchman,<sup>7</sup> in explaining the mechanism of this parallelism, states that "the factor which determines the relation of an organism to the gram process of staining is not the same as the factor which determines its relation upon divided gentian violet plates or after staining with the dye."

Nevertheless, combined with the gram stain, a "gentian" positive or "triphenylmethane" positive dye contains certain groups possibly related, as Crossley states, to the substituted alkyl radicals for the aminohydrogen of the basic nitrogen. These combinations when added to the "reactive groups" of the structure of the organism combine with them and later are fixed by the iodine solution which acts as a mordant and prevents the redissolution of the dye. This process definitely takes place in fixed or dead organisms. The same reaction may occur in the instance of living organisms, save that here the combination of dye with the "reactive groups" of the organism results not in mere staining of the parasite, but prevents further metabolism and division on the part of the bacterium by effecting some change in the tissue structure of the organism. At any rate, this idea must be kept in mind when considering the action of this group of substances.

Krumwiede and Pratt<sup>8</sup> not only verify the statements of Churchman, but state that occasionally there is found a particular strain of a gram-negative organism, which will not grow upon gentian violet mediums. This strain of organism was found to differ from other strains of the same organism by agglutination tests, which may account for the noninhibition in the same dilution of dye.

Krumwiede<sup>9</sup> recently made a brilliant green agar for the isolation of typhoid bacilli. Brilliant green, a diaminotri-phenylmethane derivative, they found not only inhibited gram-negative organisms but also many types of gram-positive bacteria as well. It exerted a specific differential action upon the colon-typhoid group. *B. lactis aerogenes*

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7. Churchman, J. W.: The Cause of the Parallelism Between the Gram Reaction and the Gentian Violet Reaction, *Proc. Soc. Exper. Biol. & M.* **18**: 17, 1920.

8. Krumwiede, Charles, and Pratt, J. H.: Observations on the Growth of Bacteria on Media Containing Various Aniline Dyes, *Proc. New York Path. Soc.* **13**:43, 1913; *Dahlia Agar als Unterscheidungs Mittel Zwischen Cholera und Anderen Vibrionen*, *Centralbl. f. Bakteriologie*, **58**:585, 1913.

9. Krumwiede, Charles: Footnote 8. Hiss, P. H., and Zinsser, H.: *Textbook of Bacteriology*, New York, D. Appleton & Co., 1919.

and the paratyphoid organisms are not affected, and *B. typhosus* is inhibited only in lower dilutions, whereas dysentery and the other colon groups are inhibited.

#### APPLICATION OF SPECIFIC CHEMOTHERAPY TO INFECTED WOUNDS

Such information as this stimulated many clinical workers to investigate the possible application of specific chemotherapy to cases of infected wounds.

Consequently, Leitch<sup>10</sup> used brilliant green 1:1,000 in aqueous solution and in normal saline solution as an antiseptic for infected wounds. He very soon observed that vital tissue under the action of the dye retained its normal appearance and color, whereas dead or necrotic tissue was deeply stained with the dyestuff. He also noted that the dye appeared to exert a more selective action upon staphylococci than upon streptococci.

A short while later, Short<sup>11</sup> reported upon the injection of a paste, composed of boric acid, French chalk, and brilliant green 1:200 in liquid petrolatum, into the sinuses of infected wounds with excellent results. They injected a 1:200 aqueous solution of brilliant green into the wound just before injecting the paste. They also maintained that there was no tissue destruction on the part of the dye and asserted that it was mildly stimulating to granulation tissue.

Browning, Gulbransen and Thornton<sup>12</sup> tested acriflavine, proflavine and brilliant green with especial reference to their suitability to wound therapy. They found in the test tube that brilliant green 1:2,000 aqueous solution is 500 times as toxic for a twenty-four hour broth culture of *Staphylococcus aureus* as is Dakin's solution, and it is 700 times as toxic as Dakin's solution for *B. coli*. Consequently, they used repeated irrigations of 1:2,000 aqueous solution of brilliant green to infected wounds and obtained excellent results. Furthermore, they found that it was absolutely innocuous to vital tissues and also that the dye is not reduced or hampered in any way in its activity by tissue juices and wound secretions. They did note, however, that blood serum in the test tube does reduce the activity of brilliant green in its toxicity for bacteria.

Later on, Browning<sup>13</sup> ascertained that brilliant green will kill gram-positive cocci in dilutions of 1:100,000. He also says that in dilutions

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10. Leitch, A.: Brilliant Green as an Antiseptic, Brit. M. J. **1**:236 (Feb. 1) 1916.

11. Short, A. R.; Arkle, J. S., and King, C.: Brilliant Green Paste in Wounds, Brit. M. J. **2**:506 (Oct. 20) 1917.

12. Browning, C. H.; Gulbransen, R., and Thornton, L. H. D.: Acriflavine, Proflavine and Brilliant Green with Reference to Suitability to Wound Therapy, Brit. M. J. **2**:70, 1917.

13. Browning, C. H., et al.: Brilliant Green in Infected Wounds, Brit. M. J. **1**:73 (Jan. 20) 1917.

of 1:500, it stimulates phagocytosis. Similar results were obtained by Webb<sup>14</sup> and by Ligat,<sup>15</sup> both of whom used a 1:1,000 solution as irrigations in infected wounds. J. E. Adams,<sup>16</sup> in the treatment of erysipelas, used a 5 per cent. aqueous solution of brilliant green, picric acid and tincture of iodine in separate, yet comparable, cases, and concluded that the dye gave the most satisfactory results. It was painted upon the affected skin surface once or twice a day, according to the severity of the infection. No dressing was necessary, save to protect the clothing.

J. W. Churchman<sup>4</sup> used dilutions of gentian violet in the treatment of purulent arthritis. He first tapped the joint to ascertain the type of infection. The joint was then lavaged and stained as outlined in a previous article.<sup>17</sup> He obtained a cure with good functional results in these types of joint infection: *Staphylococcus aureus*, two cases; pneumococcus, one case, and, gonococcus, four cases.

One lavage and staining was sufficient to procure an uneventful recovery in each case.

He<sup>18</sup> also treated several infected wounds of the skin and serous membranes with excellent results. He suggested the use of solutions of dye injected into the gums in the treatment of infections deeper in the tissues as well as superficial gingivitis. He prefers the term "bacteriostasis" to "bactericidal" in speaking of the action of dyes upon organisms.

Mackie<sup>19</sup> endeavored to clean up diphtheria carriers by using a spray of an aqueous solution of brilliant green (1:250 or 1:500) into the mouth and pharynx. He sprayed, three times daily, for one week, and asserts that he obtained negative cultures after such a spray.

This work was repeated by Kolmer,<sup>20</sup> who also used a 1:250 solution of brilliant green. He found that the disappearance of the diphtheria bacilli was merely temporary. He did not note permanent disappearance of the organisms.

14. Webb, C. H.: The Value of Brilliant Green as an Antiseptic, *Brit. M. J.* **1**:870 (June 30) 1917.

15. Ligat, D.: Brilliant Green and Flavine in Infected Wounds, *Brit. M. J.* **1**:78 (Jan. 20) 1917.

16. Adams, J. E.: A Note on the Treatment of Cutaneous Erysipelas with Brilliant Green, *Brit. M. J.* **2**:779 (Nov. 20) 1920.

17. Churchman, J. W.: The Treatment of Acute Infections of the Joint by Lavage and Direct Medication, *J. A. M. A.* **70**:1047 (April 13) 1918.

18. Churchman, J. W.: Selective Bacteriostasis in the Treatment of Infections with Gentian Violet, *J. A. M. A.* **74**:145 (Jan. 17) 1920.

19. Mackie, H., cited by Browning, C. H.: *Applied Bacteriology*, Oxford University Press, London, 1918.

20. Kolmer, J. A.; Woody, S. S., and Yogle, E. M.: The Influence of Brilliant Green on the Diphtheria Bacillus, *J. Infect. Dis.* **26**:179 (Feb.) 1920.

Graham Smith,<sup>21</sup> who was investigating the value of acriflavine, proflavine (acridin dyes, derivatives of acridin, a base found in coal tar<sup>22</sup>) and crystal violet, found that the toxicity or inhibitory power depends to a great extent upon its alkalinity. Thus crystal violet inhibits *Staphylococcus aureus* as follows: 0.15 per cent. tenth normal hydrochloric acid, 1:1,500,000; 0.08 per cent. tenth normal sodium hydroxid, 1:3,500,000, and 0.58 per cent. tenth normal sodium hydroxid, 1:5,000,000.

From this it can be seen that the dye is three times as toxic for *Staphylococcus aureus* in alkaline solution as it is in acid solution, within certain limits.

Churchman has utilized chiefly gentian violet, which, as he says, is but 90 per cent. effective in its selectivity of gram-positive organisms, and only 10 per cent. effective against gram-negative organisms. He fails altogether to recognize the value of such dyes as brilliant green, whose sphere of selectivity is the gram-negative type of micro-organisms. Thus, in using a mixture of brilliant green and crystal violet

TABLE 1.—COMPARISON OF ACTION OF GENTIAN VIOLET AND CRYSTAL VIOLET

Location	Hours	No. Cases	Sterile
Abdominal skin.....	6	22	22
Peri-anal skin.....	3	20	Growth in two of four streaks in one case; growth in one of four streaks in two cases.

one would have a therapeutic agent whose selectivity was not only 100 per cent. effective against gram-positive organisms, but against gram-negative ones as well.

Browning<sup>23</sup> compared the action of gentian violet and crystal violet and found them to be practically identical in action. In sterilizing the skin, he used a mixture of 1 per cent. each of brilliant green and crystal violet in 50 per cent. alcoholic solution. He washed the skin off with the solution and applied a compress soaked with it. He obtained the results given in Table 1.

In order to ascertain what becomes of the dye in the animal body, much work has been done. Perhaps the most authoritative of which was done by Churchman.<sup>4</sup> He injected solutions of gentian violet into the marginal vein of a rabbit's ear, and one and one-half hours

21. Graham-Smith, G. S.: Some Factors Influencing the Action of Dyes and Allied Compounds on Bacteria, *J. Hygiene* **18**:1, 1919.

22. New and Nonofficial Remedies, *J. A. M. A.* **73**:1443 (Nov. 2) 1919.

23. Browning, C. H.: Footnote 20, second reference. Browning, C. H., and Bonney, V.: Sterilization of the Skin and Other Surfaces with a Mixture of Crystal Violet and Brilliant Green, *Brit. M. J.* **1**:562 (May 18) 1918 and Footnote 4.

later, when blood was drawn from the ear, no dye could be demonstrated by its bacteriostatic power. This was not due to mere contact with the blood as he proves, nor was it due to oxidation on the part of the blood. Venous blood and arterial blood proved the same in their actions.

When the dye was taken up by epithelial cells it did not break down so rapidly—the change was much more gradual. There was no tissue destruction on the part of the dye when used in dilute solutions. At the same time, the dye persisted in the tissues unchanged for sufficient time to produce bacteriostasis before it was finally disposed of. This valuable property is not found in other bacteriostatic substances.

Strasznor<sup>24</sup> found that methylene blue was reduced by ( $-SH$ ) sulfhydryl groups in the tissues. This activity on the part of the tissues is reduced by heating them, but is restored again by the addition of tissue containing ( $-SH$ ) sulfhydryl groupings. It is entirely possible that the sulfhydryl grouping may be responsible for the reduction in vital tissue of members of the triphenylmethane derivatives as well.

#### BACTERIOSTATIC VALUE OF BRILLIANT GREEN AND CRYSTAL VIOLET

As a result of these findings we have undertaken to ascertain the bacteriostatic value of brilliant green and crystal violet when acting together in solution, and to standardize, if possible, the technic of application of such solutions.

In the following experiments Grübblers' dyes were used except where specially indicated.

We have repeated in part the experiments of Browning, by first swabbing the skin of the abdomen and about the anal orifice with a mixture of 1 per cent. brilliant green and 1 per cent. crystal violet in 50 per cent. alcohol. Cultures were made of a series of cases by scratching the skin with a sterile needle and stroking an agar plate. Four strokes were made in each case, the needle being flamed between strokes. Cultures were made of another series after painting the skin surface as above, but in addition, applying a compress soaked in the dye and later taking cultures in the manner just described (Table 2).

A third series of experiments was conducted thus: The skin was washed with soap and water and rinsed with 4 per cent. sodium bicarbonate solution. Following this a compress of aqueous solution of 1 per cent. each of brilliant green and crystal violet was applied. Cultures were made of areas so treated as heretofore described.

24. Strasznor, Walter: Die Reduzierenden Wirkungen des Gewebes, *Biochem. Ztschr.* **29**:295, 1910.

The time element in each case was five hours in the following series of cases, from which one would conclude that it is necessary to apply the compress about the anus, in order to obtain sterility in 100 per cent. of the cases (Table 3).

From the data given in Tables 2 and 3 it may be readily seen that aqueous solutions are just as satisfactory as alcoholic solutions when applied over longer periods of time.

Considerable success has been encountered in treating secondarily infected wounds of the skin and subcutaneous tissue. The first consideration is to insure free drainage and then to apply a compress soaked in aqueous solution of 1 per cent. each of brilliant green and crystal violet. This dressing should be changed two or three times a day depending upon the amount of drainage. Care should be taken to get the dye in contact with all of the wound surfaces.

The application of alcoholic solutions of mixed dye to chronic leg ulcers caused each one so treated to heal remarkably fast, whereas

TABLE 2.—COMPARATIVE RESULTS WHEN COMPRESSES WERE APPLIED AND WHEN NOT APPLIED

Location	—No Compress—		—Compress Applied—	
	No. Cases	Sterility	No. Cases	Sterility
Abdominal skin.....	10	6	16	16
Peri-anal skin.....	18	8	12	12

TABLE 3.—RESULTS OF APPLICATION OF COMPRESS ABOUT THE ANUS

Location	No. Cases	Sterile
Abdominal skin.....	13	13
Peri-anal skin.....	13	13

other cases, quite similar but treated otherwise, showed no sign of closing over.

Similar results have been obtained in the treatment of chancroidal infections.

Mr. E. W., single, aged 53, had large varicose veins of both legs with an ulceration 3.5 cm. in diameter on the lower third of the right tibia. The ulcer has been present and draining for seven months without a sign of closing over. The patient, without stopping his regular work, was treated with daily applications of 1 per cent. brilliant green and 1 per cent. crystal violet in 50 per cent. alcohol for five days. At this time, the discharge had practically stopped and healthy granulations had formed at the base, epithelium growing in from the edges. The dye therapy was continued three times a week for two weeks more, when the ulcer had entirely healed.

The hydrogen ion concentration ( $p_H$ ) of saliva varies greatly in different individuals, and also in the same individual from time to time. This change may be brought about by changes in diet, appetite and

general health, by psychic changes, and by a pathologic condition of the oral and gastric mucosa and teeth. Bloomfield<sup>25</sup> finds that the saliva from normal people varies between  $p_H$  6.0 and  $p_H$  7.3<sup>26</sup> and that 80 per cent. of the specimens fell between  $p_H$  6.6 and  $p_H$  7.1. Persons who were suffering from a variety of diseases had a slightly wider range ( $p_H$  5.8 to  $p_H$  7.5) than was found in the normal group.

I<sup>27</sup> likewise examined a series of specimens of saliva of normal people and found that the average was  $p_H$  7.43.<sup>26</sup> This is fairly alkaline and is sufficient to enhance the value of crystal violet and brilliant green when acting in the oral cavity. It has been demonstrated in previous work that these dyestuffs are more effective in alkaline than in acid mediums.

For this reason, I recommended the use of a mouth wash of 4 per cent. sodium bicarbonate solution after carefully brushing the teeth with an alkaline tooth powder. Then a mixture of 1 per cent. each of brilliant green and crystal violet in 50 per cent. alcohol was applied to the surface of the gums. Three minutes later, cultures were taken from this area and proved sterile. Further observations showed that the alcohol alone did not account for the sterility obtained. Aqueous solutions of the dye used over a very limited period of time (2.5 minutes) did not give the same result, and it was concluded, in order to obtain the result sought in the shorter period of time, that the alcohol was necessary to carry the dye. No experiments were undertaken at that time to test the value of aqueous solutions over longer periods.

Infected maxillary sinuses are thoroughly irrigated with sodium bicarbonate solution by means of a trocar passed through the mesial wall below the inferior turbinate, and then injected with from 2 to 3 c.c. of aqueous solution of the mixed dye. The treatment may be repeated every day for several days, depending upon the severity of the case. In all, twenty patients have been treated in this manner, with excellent results in twelve. The cases of six of the remaining eight patients were complicated by further sinus infection and were only temporarily relieved, and two patients had open sinuses into the oral cavity, reinfection taking place very rapidly afterward.

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25. Bloomfield, A. L., and Huck, J. G.: The Fate of Bacteria Introduced Into the Upper Air Passages. IV. The Reaction of Saliva, *Bull. Johns Hopkins Hosp.* **31**:118 (April) 1920.

26. According to the colorimetric method of Clark, U. M., and Lubs, H. A. (The Colorimetric Determination of Hydrogen Ion Concentration and Its Application to Bacteriology, *J. Bacteriol.* **2**:191, 1917) and of MacLeod, J. J. R., (The Diagnosis of Acidosis, *J. Lab. & Clin. M.* **4**:315 [March] 1919).

27. Berwick, C. C.: The Disinfection of the Oral Mucosa with Brilliant Green and Crystal Violet, *J. Dental Res.* **2**:21, 1920.

A large ulcer on the posterior pharyngeal wall had remained unchanged for a long time under treatment with ordinary drugs. After three applications of the dye in alcoholic solution at twenty-four hour intervals, granulations formed at the base of the ulcer and it healed in a very short time.

Acute pharyngitis and tonsillar ulcers are likewise benefited by frequent applications of alcoholic solution of mixed dyes.

The following is an outline of procedure for cleaning up gross infections in the mouth preparatory to surgical operations in the mouth, nasopharynx, larynx or trachea. First, the teeth are thoroughly cleansed by carefully brushing all surfaces with a hard, small, baby's tooth brush, using a mixture of equal parts of talc and sodium bicarbonate. Care must be taken not to brush the gums, for then tissue destruction will take place at a faster rate and the infection will be the more difficult to eradicate. This brushing should be done carefully and systematically, taking at least from ten to fifteen minutes to the entire mouth. The mouth is then washed out with an alkaline wash, either a 4 per cent. solution of sodium bicarbonate or the ordinary liquor alkalinus antisepticus solution. Following this, the gums and necks of the teeth should be painted with a 50 per cent. alcohol solution containing 1 per cent. each of brilliant green and crystal violet. Care should be taken to get the dye in between each tooth, and where it may enter the pyorrheal pockets about the necks of the teeth.<sup>28</sup>

This procedure should be carried out once the first day, twice on the next day, if possible, and once several hours preceding the operation.

This technic has been successfully carried out in many cases of oral and dental surgery, as well as in three cases of laryngectomy and several cleft palate operations.<sup>29</sup>

After operation in mouth cases, it is of benefit to swab the mouth and wound surface with alcoholic solutions of the dye at frequent intervals. This not only hastens the healing process but also serves to lessen the pain to a great extent, as illustrated by the case herewith reported.

Mr. J. A. P., aged 39, had osteomyelitis of the left mandible. The technic just described was carefully carried out before operation, and at operation the infected portion of the jaw was removed and drained. The wound was dressed

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28. Considerable work is still being done to determine the effect of dyes on pyorrheal infections (*J. Dental Research* 2:21, 1920) and we may state only that so far our observations tend to show that the dyes exert their action by merely temporarily lessening the symptoms caused by the infecting organisms. The tendency toward tissue destruction remains more or less unchanged.

29. This technic has been adopted as the standard in the University of California Hospital, standing orders for cleaning up of gross infection in the oral cavity, preparatory to oral and neighboring operations.



daily with gauze packs soaked in 1 per cent. each of brilliant green and crystal violet (aqueous). In six days, there was no more discharge, and the packs were no longer inserted. In ten days the soft tissue had entirely healed over. Roentgenograms later revealed no local pathologic condition.

For rectal cases, this method gives excellent results: Repeated soapsuds enemas are given until they return perfectly clear on the night previous to operation. The operative field, if about the anus, is shaved and painted with 1 per cent. brilliant green and 1 per cent. crystal violet in 50 per cent. alcoholic solution. Then about 20 c.c. of a 1 per cent. aqueous solution of brilliant green and crystal violet solution in aqueous solution is injected into the rectum and sterile dressings applied. On the morning of operation, the injection of aqueous dye into the rectum is repeated and the sterile dressings reapplied. When colostomy has been performed, the dye may be injected into the descending loop of the bowel before performing the Kraske or similar operations.

Postoperatively, the injection of from 10 to 20 c.c. of aqueous solution of dye into the rectum is of great benefit in the healing process, and the alleviation of pain is quite marked in many cases so treated.

Excellent results were obtained in four cases of resection of the rectum for carcinoma as well as in eight cases of hemorrhoidectomy.

Injection of the aqueous solution into rectal fistulas is of benefit in their excision, when they do not heal after repeated injections of dye into them. These fistulas may be easily located at the time of operation by the dark blue-violet color of their walls.

Ischiorectal abscesses, when irrigated with aqueous solutions of dye, heal more rapidly than with other substances. Of three cases so treated, the alleviation of pain was one of the marked features of the treatment, whether it was due to the cutting down of the infection or not could not be definitely determined.

Equally good results have been obtained in the treatment of unopened secondarily infected tuberculous abscesses in the ileopsoas muscle. The abscess cavity is aspirated of its contents by the use of an aspirating needle or small trocar. The cavity is then irrigated with a 4 per cent. solution of sodium bicarbonate until the fluid returns clear. A small amount of the soda solution is left in the cavity in order to maintain its alkalinity, and a small quantity of 1 per cent. aqueous solution of brilliant green and crystal violet is injected into it. The amount injected varies according to the size of the cavity. In a short time (from twelve to forty-eight hours), depending upon the nature of the infection and the size of the cavity, it will be found that the necrotic material is sterile. It then remains to permit the cavity to granulate in, with occasional lavages administered to remove whatever tissue débris remains in the cavity.

This method has been successful in six cases of *Staphylococcus albus* infection and one of *B. coli* infection of deep muscular tissues. In four cases of psoas abscess, the treatment was successful so far as it produced sterile cultures, but it was not possible to get at the source of the infection in the lumbar vertebrae. In three of these cases, the abscess cavity broke through the line of puncture and drained for a long time. The secretion not only was sterile upon ordinary enrichment mediums; but guinea-pig inoculation was negative for tubercle bacilli. These patients all died some time later from pulmonary involvement. No effort was made to ascertain the effect of the dye upon tubercle bacilli either clinically or in vitro, other than the above.

It has also been our observation that dead or necrotic tissue takes a deep stain and maintains it for a considerable period of time. This does not wash off with either alcohol or water to the extent that the dye does from vital tissue. Living tissue does not keep this heavy stain for so long a period of time, but the dye gradually becomes less intense until one can notice no stain remaining. This may be due, as Strasznor<sup>24</sup> has shown, to certain sulfhydryl groups inherent in the living cell. This activity is perhaps lost when the tissues undergo the process of decomposition, either by a catabolic or destructive action on the part of infective organisms.

#### ADVANTAGES AND DISADVANTAGES

The advantages of the use of dyes as antiseptics may be briefly listed thus: (1) specific selective action; (2) nontoxicity to vital tissues; (3) high alcohol and water solubility; (4) great penetration, and, (5) ease of application.

The possible objectionable feature of the dyes as antiseptics is the almost excessive staining quality. Considerable difficulty is experienced at first by those who use the dye, in trying to prevent staining of contiguous clothing and skin when not desired. With experience, however, one accustoms himself to its use, and the staining of other areas becomes less objectionable. This dye may be removed by immediate washing with alcohol, or acid alcohol, or by applications of, first, oxalic acid solution, and then water, repeated alternately until the stain is entirely removed. Hypochlorite solution is also of value in removing these stains. The same is true of the removal of dye from undyed cloth.

#### SUMMARY

There is a definite place for certain dyes in the treatment of wound infections. These dyes are extremely valuable on account of their selective bacteriostatic action, their low tissue toxicity and their ease of application.

## FIFTEENTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY \*

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### TUBERCULOSIS

*Tuberculous Rheumatism.*—Duvernay<sup>1</sup> states that while the existence of the tuberculous rheumatism of Poncet is generally recognized, there are many erroneous conceptions concerning its pathology and treatment. He believes that the joint symptoms represent an antitoxic or reactional phenomenon, and that there is no evidence to suggest the presence of the Koch bacillus in the joints affected. When the toxic substances are abundant, tuberculous rheumatism seldom appears. He considers it a symptom of convalescence when the organism is defending itself and the antibodies are very abundant. This conception has important bearing on rational treatment, and Duvernay's recommendations are that the local therapy should be the therapy of any nontuberculous arthritis, viz., warmth and immobilization in the acute stage, but mobilization and massage as early as possible to avoid atrophy and ankylosis.

[Ed. Note.—Our experience with true tuberculous rheumatism has been slight, but in certain rather typical and apparently genuine cases our observations have seemed to confirm these statements and theories of Duvernay. It is certainly very rare to encounter this acute or subacute polyarthritis in patients with active true tuberculous monarticular or spinal lesions, and it has been true that the polyarthritis has gradually disappeared without noticeable change in the monarticular disease and while it was in an inactive stage.]

*Tuberculosis of the Spine.*—DeMata<sup>2</sup> reports favorable results in thirty-five cases of vertebral tuberculosis treated by Albee's spinal grafts. In two cases of compression paraplegia, no change in the condition followed the implant.

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\* This report is based upon a review of 673 articles selected from about 900 titles having to do with surgery of the extremities and spinal column appearing in medical publications, chiefly from July, 1919, to July, 1920. Only those papers seeming to represent progress in this branch of surgery have been selected for abstract and editorial comment.

1. Duvernay: Lyon méd., April 10, 1920.

2. DeMata: Med. Ibera, Nov. 15, 1919.

In 405 patients with tuberculous caries of the spine treated at the Mayo Clinic, the spinal graft was employed by a modified Albee technic in 100. Meyerding's<sup>3</sup> conclusions, from a study of these cases, are (1) that a proper selection of cases is important; (2) that a continuance of conservative treatment after the operation and until the disease process has been arrested is necessary to insure good results.

Calvé<sup>4</sup> insists that ankylosing operations are useless in the early stages of Pott's disease in children, but are indicated in adults. His reasons for this dictum are that adults do not possess the power of spontaneous recovery peculiar to childhood, and complete consolidation is more rare, so that they require, without an ankylosing operation, some form of support, indefinitely. He describes his modification of Hibbs' operation, which he considers more applicable than the Albee graft to all dorsal regions. He reports excellent results from the latter grafting operation in the lumbar region.

Ely<sup>5</sup> reports the case of a boy of 4 on whom first a Hibbs' operation and later an Albee operation had been performed, followed by constant recumbency and heliotherapy. In spite of all these measures the disease progressed to a fatal termination, although necropsy showed a firmly ankylosed spine. Ely believes that ankylosing operations are curative in a large number of cases, but not invariably so. He considers them serious operations, with a rate of mortality by no means negligible. He believes the operation of Hibbs to be more rational and successful, but also more difficult.

Doché<sup>6</sup> has studied 140 cases of caries of the spine in soldiers at the sanatorium under his charge at Arcachon on the coast of France near Bordeaux. He was impressed with the fact that in a large number of cases the obvious diagnosis had not been made. While only two thirds of the patients had general rigidity of the spine, hyperextension was absolutely blocked in all. He states that under heliotherapy and recumbency all his patients, except those with sinuses, recovered, while the mortality was high among those with infected fistulas, and that the tragedy of these was that most of the infected sinuses came from misdirected surgical zeal in opening abscesses. All his patients were kept in recumbency for from six to eight months after the last clinical symptom had disappeared. Large abscesses were punctured and infected fistulas were adequately drained and irrigated by the Carrel-Dakin technic. This method seemed to promise better results, but his experience is too recent for a decisive judgment.

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3. Meyerding: *Minnesota Med.*, June 12, 1920.

4. Calvé: *Presse méd.*, Jan. 7, 1920.

5. Ely: *Ann. Surg.*, Dec., 1919.

6. Doché: *Presse méd.*, Jan. 14, 1920.

*Tuberculous Abscesses.*—Portman<sup>7</sup> calls attention to the importance of differential diagnosis between mastoiditis and suboccipital Pott's disease. If there is no cervical abscess, the pain is sharply accentuated in Pott's disease by movements of the head, in mastoiditis by pressure. In Pott's disease there are no eye symptoms. In mastoiditis, eye symptoms are common. In Pott's disease the pain in the region of the abscess is slight; in mastoiditis, severe. The abscess swelling in Pott's disease is regular and not usually inflamed; in mastoiditis its outlines are not sharply defined, and there is peripheral infiltration. Puncture of the abscess in Pott's disease releases a thin, lumpy pus; in mastoiditis the pus will be phlegmonous, thick, and of uniform consistency. The sinus runs toward the spine in the one; toward the mastoid in the other. Roentgenograms will be characteristic in each.

Durante<sup>8</sup> has obtained excellent results in 400 cases of cold abscess by evacuating the cavity by punctures and filling it with a hypertonic salt solution, which induces by osmosis a profuse secretion of lymph and attracts lymphocytes to the focus. The solution which in his hands has proved the most efficacious is a 2.5 per cent. solution of magnesium chlorid in distilled water, with 10 drops of liquor formaldehydi per gram added when cold. After clearing out the abscess, the cavity is rinsed and then filled with this solution about every four days, from 10 to 40 c.c. of the fluid being used.

*Therapy.*—Tuberculin: Kleinberg,<sup>9</sup> after a thorough discussion of the literature and a personal study of twenty bone and joint cases, concludes that tuberculin does not cause tuberculosis of the bones and joints, and in the great majority of cases it brings about no beneficial results. In some cases there seems to be an improvement and in some an aggravation of symptoms, new abscesses appearing and relapses occurring after apparent amelioration.

*Operative Procedures in Children:* Schwamm,<sup>10</sup> an assistant of Lorenz, publishes an illustrated report of results following resection of tuberculous knee joints in children. In all of them marked deformities had developed, some of them of a very serious nature. Flexion was most common, but genu valgum and recurvatum were frequent. Of great importance is the statement that these deformities may not develop for many years after the operation. The operation, if it be necessary, should not be considered as dispensing with long continued after-treatment.

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7. Portman: *Rev. de chir.*, Nov. and Dec., 1919.

8. Durante: *Policlinico*, Rome, Sept. 21, 1919.

9. Kleinberg: *J. Orthop. Surg.*, Dec., 1919.

10. Schwamm: *München. med. Wchnschr.*, 1920, p. 1145.

[Ed. Note.—It is perhaps not amiss to point out these unhappy results of radical surgery of tuberculous joint disease in childhood, since with improved technic there is still a tendency on the part of certain surgeons to attempt completely to eradicate the disease by resection of the joint in children. The healing of the wound and the ankylosis of the joint is by no means the end of the story.]

Heliotherapy, Artificial Light and Roentgen-Ray Treatment: Bier<sup>11</sup> gives heliotherapy the first place in the successful treatment of tuberculosis of the bones and joints. He advocates orthopedic apparatus for the relief of weight-bearing and for correction of deformity, but not for fixation. Open operations he discountenances except for correction of deformity and for the removal of sequestrums. Bier believes that the artificial sunlight lamps are excellent substitutes for actual sunlight. He believes that the beneficial effect of sun rays is nearly equal in the mountains and on the plains.

Oehlecker<sup>12</sup> employs the same methods as Bier, except that he still uses iodoform injections, which Bier has discarded.

Lovett<sup>13</sup> discusses the use of the Thézac-Porsmeur method of sun treatment of tuberculosis. The principle is the use of a double convex lens of 72-inch focus, concentrating the rays in a circle about 3 to 5 inches in diameter. With this apparatus the length of time of treatment may be lessened and the effort concentrated on diseased areas. Lovett believes that the effect on his cases of surgical tuberculosis with discharging sinuses has been encouraging.

Berntsen<sup>14</sup> has studied the effect of the so-called coal arc light on the blood, and states that the changes he has noted are within physiologic limits.

Very encouraging reports come from the Finsen Institute in Denmark in an article by Ernst<sup>15</sup> on the use of this coal arc light. Most of the patients were outpatients, and no forms of fixation in the bone and joint cases were used. Weight bearing was not permitted in joints of the lower limbs. Unusually good results were obtained in tuberculosis of the soft tissues, spina ventosa, elbow, wrist, ankle, and knee cases, but less favorable results in hip and spinal disease.

In a further report by Ryer and Ernst,<sup>16</sup> the authors find this coal arc lamp much superior to the mercury lamp, as regards both its penetration and the kind of pigmentation of the skin which it produces.

11. Bier: *Berl. med. Wchnschr.*, 1918, No. 31.

12. Oehlecker: *München. med. Wchnschr.*, 1918, No. 9.

13. Lovett, R. W.: *The Tripod Method of Walking with Crutches*, J. A. M. A., **74**:1306 (May 8) 1920.

14. Berntsen: *Hospitaltid.*, April 24, 1918.

15. Ernst: *Hospitaltid.*, May 9, 1917.

16. Ryer and Ernst: *Hospitaltid.*, May 9, 1917.

Schanz<sup>17</sup> points out that the chief advantage from altitude in heliotherapy seems to be derived from the fact that the sun's rays are, in lower planes, lacking in the ultraviolet rays. This is also characteristic of the rays from the coal arc lamp.

The aureole lamp, whose rays are said to most closely resemble sunlight, is recommended by Kisch<sup>18</sup> and Baugert.<sup>19</sup>

Roentgen-ray therapy for bone and joint tuberculosis has been employed in more than 300 cases in Eiselberg's clinic in Vienna, and the results have been reported by Kapelusch and Orel.<sup>20</sup> They have employed aluminum filters of from 3 to 4 mm., thus avoiding skin burns.

Fixation is used for the relief of pain only. Their goal is a movable joint.

Another report from the same clinic two years later, by Kapelusch and Stracker,<sup>21</sup> describes an extension of the method to the preoperative treatment, by roentgen rays, of periarticular foci. They say that the tuberculous tissue is melted out, as it were, and separated from the surrounding tissue by a wall of granulations. The cavity is opened and drained with a glass tube. Radiation is begun again in 2 or 3 days and repeated every week or two.

Espinola<sup>22</sup> believes that roentgen-ray treatment in the bone and joint tuberculosis of children is of great value. The results of his experience have been very satisfactory, especially when combined with heliotherapy.

Briton<sup>23</sup> has followed, since 1912 and 1913, three cases of tuberculosis of the foot, of the elbow, and of the lumbar spine, in adults, which had been treated by roentgen rays. The elbow lesion had existed for five years, and both the elbow and the spine had been opened surgically and curetted. Apparently complete cures are reported in all these cases.

[Ed. Note.—One interesting tendency which these reports on tuberculosis show is the lessened importance which certain surgeons are attributing to fixation in bone and joint tuberculosis. In fact, painless motion is considered by certain observers actually to favor recovery, though all seem to agree that weight bearing is contraindicated. All agree that surgery is to be avoided if possible in children, and that a greater and greater reliance can safely be placed on not only helio-

17. Schanz: *Ztschr. f. diätet. u. physik. Therap.* **38**:705, 1917.

18. Kisch: *München. med. Wchnschr.*, 1917, No. 17.

19. Baugert: *Ztschr. f. diätet. u. physik. Therap.* **40**:271, 1918.

20. Kapelusch and Orel: *Wien. klin. Wchnschr.*, 1917, 18.

21. Kapelusch and Stracker: *Wien. klin. Wchnschr.*, 1919, 43 and 44.

22. Espinola: *Semana méd.*, Oct. 30, 1919.

23. Briton: *Presse méd.*, June 12, 1919.

therapy, but also other forms of radiant activity. The reports from the use of the coal arc and aureole lamps seem to indicate that they have greater therapeutic value than the old mercury lamps. In the light of the results attributed by careful observers to the use of regulated and aluminum-filtered roentgen rays, it is quite possible that we have been neglecting this therapeutic possibility in this country. One of the editors has observed an old discharging tuberculous elbow in an adult, in which two guinea-pig tests were positive, heal completely and become quite freely mobile under roentgen-ray treatment. A long series of roentgenograms have shown apparently complete healing, which has persisted in spite of free use for over four years.]

#### SYPHILIS

*Joint Syphilis.*—Lacapère and Laurent<sup>24</sup> of the Dispensaire Anti-syphilitique, at Fez, Morocco, have examined 1,200 cases and find that among the 178 Europeans no case of joint involvement occurred, while 112 of the 979 Mohammedans showed joint lesions. They estimate that 75 per cent. of the native population are syphilitic. In the colder months the percentage of joint lesions jumps from 10 to 28, and they have come to believe that malaria is another predisposing factor. Some of the patients having "syphilitic rheumatism" developed ankylosis, and some developed fistulas. Apparently the knees, elbows, and shoulders were the joints most commonly affected.

Roberts,<sup>25</sup> in three articles, emphasizes the importance of the most careful investigation of all supposedly tuberculous joints in relation to obscure inherited or acquired syphilitic taint. He states that he has had under treatment 200 cases of bone and joint diseases which showed the classical symptoms of tuberculosis, but which were "undoubtedly" of syphilitic origin. They either had positive Wassermann tests, showed definite signs of inherited syphilis, or were relieved of all symptoms by an intensive treatment with mercury and iodids. He reports ten cases of Legg-Calvé disease (osteochondritis juvenilis) of the hip, which he believes were due to inherited syphilis. Pain was relieved and motion became more free after administration of mercury and potassium iodid. The roentgen-ray examination revealed little change in the character of the lesion. Roberts considers that these specific joints need the protection of a convalescent splint, in weight bearing, but that the immobilization and restriction of function should be less complete than is customary in tuberculosis.

24. Lacapère and Laurent: Paris méd., Sept. 20, 1919.

25. Roberts: J. Orthop. Surg., Aug., 1919; Am. J. Syphilis, April, 1920; J. Orthop. Surg., May, 1920.



Aimes<sup>26</sup> suggests that the rarity of syphilitic "Pott's" disease is probably due solely to blunders in diagnosis. He states that it is extremely rare in females, and that it is rare in inherited syphilis. He thinks the usual location is in the cervical spine. Pain is not relieved by immobilization, and night pain is common. He reports four cases of sudden death and says that complications of paralysis, dysphagia, and sphincteric trouble have been met. Tuberculosis and syphilis may co-exist and vertebral sarcoma may be secondary.

Evans and Marshall<sup>27</sup> report a case of syphilitic spondylitis in which the Wassermann reaction was negative. The absence of an abscess and of muscular atrophy, and the fact that new bone formation predominated over bone destruction, established the diagnosis.

Varisco<sup>28</sup> reports a case of osteoperiostitis developing in a young woman of 20, who had previously been healthy, except for mild convulsions in infancy and measles at 18 years. At 20, the patient began to complain of pain in the legs and the large joints. The spinal fluid was normal, and the Wassermann reaction was negative. After six months in bed the symptoms improved, but soon painful tumors appeared on the crests of the tibiae and certain of the long bones, and in the clavicles. A year after the onset of symptoms an experimental course of mercurial treatment relieved all the symptoms, while the Wassermann reaction became positive. The only suggestions of inherited syphilis which Varisco could find were the shape of the patient's teeth, and a certain pigmentation of the face. There was no immediate family history of syphilis.

Cannata<sup>29</sup> has been investigating for the last five years the possible connection between inherited syphilis and rachitis. Over 12 per cent. of the 10,000 children passing through his clinic during these five years were rachitic, and over 37 per cent. of these had inherited syphilis. There were fifty-eight breast-fed rachitic patients, in whom rickets was connected with inherited syphilis. Craniotabes, pronounced anemias, and splenomegaly, which have been considered characteristic of the association of rickets and syphilis, were equally prominent in eighteen patients under six months, who seemed to be free from all inherited taints.

[Ed. Note.—Many of the articles, especially those of Roberts, with his large series of cases, emphasize the importance of always considering the possibility of an obscure syphilitic etiology in obscure bone and joint lesions, especially in those resembling tuberculosis. The occur-

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26. Aimes: *Progrès méd.*, May 31, 1919.

27. Evans and Marshall: *Lancet*, March 20, 1920.

28. Varisco: *Rev. crit. di clin. med.*, Oct. 25, 1919.

29. Cannata: *Pediatrics*. Sept., 1919.

rence of minor lesions in other joints, ocular findings, and other stigmata of inherited syphilis should be sought. Varisco's carefully reported case is instructive, and the Editors have encountered similar very late developments of syphilitic taints. We are convinced that we constantly miss cases of syphilitic spinal diseases like those of Evans and Marshall and Aimes. We have recognized the vertebral disease in females and in children with other hereditary lesions, and while these lesions may be rare in females and children, they do surely occur. It is quite clear that we cannot rule out syphilitic disease of the bones and joints by a single or, according to Roberts and Evans and Marshall, even by repeated Wassermann tests.]

#### RICKETS, OSTEOMALACIA AND OSTEITIS DEFORMANS

Pereda,<sup>30</sup> in two papers, considers that the bony abnormality in rickets is not principally due to deficiency in calcium in the diet. Cow's milk, more rich in calcium than human milk, breeds rickets. He contends that the osteoporosis which follows deprivation of calcium in the food is not true rachitis, and never develops into rachitis as long as there is not chronic intoxication of digestive origin. The defective digestion of fats he considers the essential factor, aided perhaps by a congenital susceptibility. He believes that calcium should not be given, except that contained in rational infant food.

Corominas<sup>31</sup> ascribes to endocrine insufficiency an important share in the causation of rickets. He believes that epinephrin is a valuable drug to whip up the endocrine system.

Huldschinsky<sup>32</sup> has been studying the effect of the ultraviolet rays of artificial sunlight lamps on rickets in Biesalski's clinic. No other treatment was given during the time of application of the light, which was administered three times a week. He thinks that waves of less than 380 mm. have the most pronounced effect. Beginning with a distance of 1 meter exposure for three minutes, he gradually reduced the distance to 60 cm., increasing the time one minute at a time, until during the third month the time of exposure was twenty minutes. Roentgenograms were taken of the left forearm before the beginning of the treatment, and once a month thereafter. In all the twenty-four cases, a healing tendency was noted, appreciable in one month, and well advanced in two, when the process seemed to come to a standstill. By four months the bones appeared normal. The plates show considerable calcium deposition during the second month—not actual new bone formation, but impregnation with lime salts of the spongy bone,

30. Pereda: *Med. Ibero*, May 31, 1919; *Progresos d. la clin.*, Sept., 1919.

31. Corominas: *Arch. Españ. de Ped.*, April, 1919.

32. Huldschinsky: *Ztschr. f. orthop. Chir.* **39**:406, 1919.

which lacked these salts. Huldschinsky considers that questions as to the best form of lamp, the permanency of the healing, and the possibility of preventing the development of rickets, are still open.

Many German publications deal with the great increase in rickets and osteomalacia since and during the last years of the war. Eisler<sup>33</sup> believes these diseases with different names are one and the same, differing only in age periods and intensity.

Hass<sup>34</sup> and Fromme<sup>35</sup> report that many patients seek treatment, not only because of spontaneous fractures of the shaft, but also because of impacted fractures of the diaphysis into the epiphysis. They attribute these conditions of extensive bony atrophy solely to the lack of proper food, and have called them "Blockade Krankheit."

Hess and Unger,<sup>36</sup> in an article entitled "The Clinical Rôle of the Fat Soluble Vitamin; Its Relation to Rickets," base their conclusions on a study of 100 infants in a modern pediatric institution. They remind us that in rickets we must not lose sight of the existence of a prenatal disposition. The negro child living side by side with the white in the larger cities, and receiving the same milk supply as the white, develops rickets much more often. Rickety babies are apparently strong and healthy, and the disease frequently develops in infants receiving too much milk rich in fat, protein, and salts. The fat soluble vitamin is not in their opinion the controlling influence. They find that infants develop rickets while receiving a full amount of this principle, and that they do not manifest signs of rickets, although deprived for many months of this vitamin at the most vulnerable period of their lives. Their findings do not agree with the conclusions of Mellanby, based on his pioneer experiments on dogs, nor with the opinion of Hopkins and Clark that the fat soluble vitamin is synonymous with the "antirachitic factor."

Léri and Beck<sup>37</sup> draw a composite picture of what they call "les petits rachitiques," as the sequel of rickets in adults. They have made a study of twenty-two cases. Ordinarily, they are unnoticed, though the legs of those affected are rather short, with a tendency to genu varum, the teeth are irregular, the root of the nose is perhaps sunken, the nostrils are wide, and the mentality of low order. Under physical strain, the bones begin to ache. These patients are complaining and listless, striving to avoid effort, even the effort of speaking. In military

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33. Eisler: München. med. Wchnschr., 1919, No. 37.

34. Hass: München. med. Wchnschr., 1919, No. 25.

35. Fromme: Zentralbl. f. Chir., 1919, 26.

36. Hess and Unger: Clinical Rôle of Fat-Soluble Vitamin: Its Relation to Rickets, J. A. M. A. **74**:217 (Jan. 24) 1920.

37. Léri and Beck: Ann. de méd., Jan., 1920.

service the vagueness of their complaints and symptoms caused them to be misunderstood. No treatment other than rest, until they have reassembled their forces, has been availing.

[Ed. Note.—The experience in Germany and the study of rickets in other countries seem to confirm the opinion that rickets is a disease of nutrition and amenable to appropriate nutritional treatment. Whether the lack of one vitamin or a group of vitamins will be found to be directly responsible remains to be seen. It may possibly be that as a result of experiments now being conducted at Johns Hopkins Hospital and elsewhere, the nutritional treatment will be greatly simplified, as in scorbutus. Already we know that the administration of cod liver oil in an acute case causes a very rapid deposition of lime salts in the epiphyses. Huldschinsky's experiments with the ultraviolet rays are interesting, since according to his statement no other form of treatment was administered while the rays were being employed. However, they surely need to be confirmed, and this method will probably not take the place of well planned nutritional treatment. It may well be that the ultraviolet rays act like sunlight, which has always been considered an important factor in recovery. If this is true the advantages of concentrated dosage and constant availability are obvious.]

*Osteitis Deformans (Paget's Disease).*—Marie and Léri<sup>38</sup> describe the peculiar abnormalities found in the skulls of persons who have had Paget's disease, and the association in one case of syringomyelia.

Hauduroy<sup>39</sup> is convinced that the cause of the disease is as much a mystery as when Paget described it in 1877. In a case which he studied there was no question of acquired syphilis, though an hereditary syphilitic taint was possible.

#### PARALYSIS

*Poliomyelitis.*—Mackay,<sup>40</sup> in an article on the medical treatment of poliomyelitis, lays stress on complete anatomic rest and muscle reeducation. This complete rest should be immediate and no action of the unaffected muscle should be allowed. This complete rest should be maintained until fever, pain, and tenderness have all disappeared, and then, very slowly, muscle reeducation may begin. Commencing at the zero point of function, it may be gradually increased, and patiently and skilfully continued for at least two years.

Hurtado<sup>41</sup> has also employed this method of complete rest, with light and heat adjuvants, and is much impressed by the results.

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38. Marie and Léri: Bull. et mém. Soc. méd. d. hôp. de Paris, Oct. 31, 1919.

39. Hauduroy: Plus Ultra, Madrid, Feb., 1919.

40. Mackay: Brit. J. Child. Dis., Jan.-March, 1920.

41. Hurtado: Siglo Méd., Madrid, Dec. 20, 1919.

Escardo <sup>42</sup> comments on the three epidemics of poliomyelitis, in Uruguay, of 1906, 1912, and 1916, speaking of pain as an outstanding feature.

Figueira <sup>43</sup> considers that in poliomyelitis in Uruguay the only treatment which seemed in the least efficacious was the intraspinal injection of convalescent serum.

Rosenow <sup>44</sup> believes that herpes zoster has been shown to be an acute posterior poliomyelitis and that the serum of patients with herpes zoster neutralizes the virus of poliomyelitis. Various suggestions as to the etiology are thereby stimulated. He has isolated a pleomorphic organism from the tonsils, and, in smaller numbers, from the nervous system which, when injected into rabbits and guinea-pigs, localizes in the nervous system and produces a flaccid paralysis and nerve changes similar to poliomyelitis. He states that Amoss has shown that these streptococci are probably a nonantigenic form of the organism, which under anaerobic conditions Flexner and Noguchi have demonstrated to be the cause of poliomyelitis. Both forms have been demonstrated side by side in the tissues of poliomyelitis. In the recent epidemic in Dubuque, a serum prepared from glycerated poliomyelitis material was employed in fifty-four cases. There were three main groups of patients: (1) Those without paralysis when injected, twenty cases, all recovering without paralysis; (2) those with slight paralysis, fifteen cases; in twelve, the paralysis was arrested; in three there was slight extension; (3) those with advanced paralysis when injected, nineteen cases. Two of these died, though in one of them the paralysis was of the rapid, acute ascending type, and seemed checked for forty-eight hours. In the remaining seventeen, the paralysis seemed arrested, and in the stationary cases distinct improvement in muscle function occurred. Previous to the use of the serum, there had been the very high mortality of 47 per cent., which dropped to 4 per cent. after the use of the serum.

Flexner and Amoss <sup>45</sup> find that an effective nasal mucous membrane prevents the passage of energetically applied poliomyelitis virus into the brain and spinal cord. The normal nasal mucosa is, therefore, an invaluable defense against infection, and the number of healthy and chronic carriers of the virus is probably kept down by the protective activity of this membrane. While the exact manner and site of attack of the immune serum on the virus is somewhat conjectural, it seems probable to Flexner and Amoss that the meeting place of the virus and the immune serum is in the subarachnoid space.

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42. Escardo: *Brazil-med.*, Oct. 11 and Nov. 8, 1919.

43. Figueira: *Rev. med. d. Uruguay*, July, 1919.

44. Rosenow: *Minnesota Med.*, July, 1919.

45. Flexner and Amoss: *J. Exper. M.*, Feb., 1920.

In a study of human and experimental poliomyelitis made on cases from the 1916 epidemic in New York City, Howe<sup>46</sup> concludes that there are three pathologic types: (1) the mesodermic type, limited to the pia and the blood vessels; (2) the ectodermic type, whose main features are the degeneration of the motor cells in the anterior horns and the proliferation of the neuroglia; and (3) the mixed type. In the human cases the reaction to the virus is a mixed one, giving a variety of types.

Greene<sup>47</sup> reports that in the epidemic of 1916 there were 912 cases of poliomyelitis in Minnesota. He feels sure that especially in the rural districts the coincidence of the disease and the sequence of cases indicated strongly the spread of the disease by human contact.

Lovett's<sup>48</sup> review of the work of the Harvard Infantile Paralysis Commission is interesting as showing the thoroughness with which the work is being carried on in lessening the number of future cripples. It is a work of conservation that seeks out, at the earliest possible moment, new cases and offers them the most modern treatment. The patients are seen in special clinics or visited by trained workers. They are followed for years until, by apparatus and operation, the fullest extent of wage-earning function has been secured.

*Tendon Transplantation.*—Lorenz<sup>49</sup> and Perthes<sup>50</sup> consider that a supravaginal or paravaginal method of tendon transplantation has great advantages. The principle of this method is to unite the activating and receiving tendons above the sheath. The receiving tendon and its sheath are separated from the muscle high up and firmly united with the activating tendon and its muscle. The gliding mechanism is thus preserved. Several paralyzed muscles may thus be united with one strong, active muscle. Exercise is begun early. Samter<sup>51</sup> and Van Assen<sup>52</sup> both report excellent results in paralysis of the abductors of the hip from transplantation of the external oblique muscle into the trochanter. The insertion of the external oblique is separated from the crest of the ilium and, with the help of a strip of fascia lata or a periosteal and bony flap, turned up from the shaft of the femur, is attached to the great trochanter and the posterior surface of the femur. A cast is applied, holding the leg at 45 degrees of abduction and 10 degrees of hyperextension and inward rotation. Attempts at motion are begun in about three weeks.

46. Howe: *J. Nerv. and Ment. Dis.*, Nov., 1919.

47. Greene: *Minnesota Med.*, July, 1919.

48. Lovett: *Boston M. & S. J.*, Nov. 6, 1919.

49. Lorenz: *Zentralbl. f. Chir.*, 1917, No. 32.

50. Perthes: *Zentralbl. f. Chir.*, 1917, No. 32.

51. Samter: *Zentralbl. f. Chir.*, 1917, No. 33.

52. Van Assen: *Nederlandsch Tijdschr. v. Geneesk.*, July 5, 1919.

Szulinski<sup>53</sup> reports that he has obtained a thoroughly satisfactory result in a case of paralysis of the trapezius by drilling a hole through the middle of the spine of the scapula and passing through this a strip of fascia 25 cm. long and 3 cm. broad. The upper end of this fascia he sews to the second and third dorsal spinous processes, and the lower end to the fifth and sixth spinous processes and the tissues in the neighborhood.

Steindler,<sup>54</sup> whose excellent work on paralytic conditions of the upper extremity is well known, defines the main problems and gives his solutions as follows: (1) In regaining abduction of the shoulder, tendon transplantations have been unsatisfactory in flail shoulders. A complete or partial arthrodesis is indicated. After the shoulder muscles have been developed to their fullest extent, he does a simple arthrodesis and reefs the capsule. (2) To regain a position of flexion at the elbow, dissect off subperiosteally the whole group of forearm muscles from the external condyle and  $1\frac{1}{2}$  inches above. This flap is now sutured to the intermuscular septum 2 inches above the elbow joint. Five of ten cases show active flexion power. (3) To overcome flexion contracture of the wrist and secure stable hyperextension, arthrodesis, leaving the wrist in from 10 degrees to 30 degrees of extension, is the chosen method because in these paralytic conditions the position of hypertension is so important. After securing this stability, tendon transplantation to regain extension power in the fingers is often possible. (4) To overcome clawhand deformity and regain motion in flexion at the metacarpophalangeal joints, ingenious splints have been devised, and then tendon transplantation is resorted to, if necessary. (5) To regain for the thumb the power of apposition and active extension, tendons were transplanted.

Some of the Editors have personally observed Steindler's results and consider them extremely satisfactory.

Whitman<sup>55</sup> has devised what he terms the loop operation for paralytic equino valgus. Its purpose is to diminish the abducting forces and to increase the forces of dorsiflexion. The peroneus brevis and tertius are transplanted to the inner border of the foot. The extensor hallucis is also divided and reattached to the inner border, while the tendon of the paralyzed anterior tibial is cut higher up, looped around the tendons of the common extensor, pulling them inward and, by means of a tenodesis, fastened to the tibia after the manner of Gallie. The Achilles tendon is usually divided. Whitman's practice is to keep the foot in plaster for three months or, if very close supervision can be given, to allow in a shorter time a removable splint and exercises.

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53. Szulinski: *Zentralbl. f. Chir.*, 1919, No. 28.

54. Steindler: *J. Orthop. Surg.*, Oct., 1919.

55. Whitman: *J. Orthop. Surg.*, Aug., 1919.

Kleinberg<sup>56</sup> has slightly modified the above operation after the Biesalski-Mayer technic, by looping the anterior tibial tendon after Whitman's method, and then bringing down the peroneus brevis, tertius, and extensor hallucis together, through the sheath of the anterior tibial, and inserting them into the bone at the anterior tibial insertion.

Dunn<sup>57</sup> has written an interesting article on the treatment of calcaneo valgus. He believes that weakness of the gastrocnemius is not the all-important factor, but that the deformity is quite as much due to the unopposed tug of the tibialis anticus pulling the foot up, and of the posterior tibial and peroneus longus pulling the forefoot backward. He discusses shortening the Achilles tendon which he considers unwise; for it puts an already very weak and possibly recoverable muscle more on the stretch. In transverse tarsectomy, he says that he has found it difficult sometimes to really displace the foot backward. Astragalectomy he considers stabilizes well, but if power returns in the gastrocnemius and the other posterior muscles, the fibrous ankylosis restricts useful motion. Dunn's method, briefly, is first to tenotomize the plantar fascia through an incision on the mesial side of the foot; second, to remove a wedge of bone, base up, to correct the cavus; third, through a longitudinal incision over the back of the heel, to remove a wedge from the base of the astragalus to allow the foot to be brought down to a right angle; and fourth, to divide the peroneals on the outer side, and the posterior tibial and flexors on the inner side, threading them through the split Achilles tendon, and fixing them in a groove in the os calcis. The author believes that in any unstable paralytic foot a subastragaloid arthrodesis should form a part of any procedure for relief. It will be seen that this procedure of Dunn is based on the original operation practiced for many years by Sir Robert Jones for the relief of the same deformity. His operation was done in two stages; first, the wedge of bone from the tarsus was employed to correct the cavus, and after this had healed, the calcaneo astragaloid wedge was used to bring the foot down.

Laan<sup>58</sup> reports on seventy-five cases of paralysis of the tibialis anticus. The most successful results were obtained by attaching the extensor communis digitorum along the tibialis anticus without dividing the latter. In a few cases only half of the common extensor was used, the two peroneals and the extensor hallucis assuming the diminished function of the common extensor.

[Ed. Note.—The preservation of as nearly as possible normal physiologic conditions, and especially of the gliding mechanism, is the

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56. Kleinberg: J. Orthop. Surg., March, 1920.

57. Dunn: J. Orthop. Surg., Dec., 1919.

58. Laan: Nederlandsch Tijdschr. v. Geneesk., Aug. 9, 1919.



key note of all modern efforts to improve the technic of tendon transplantation. We have commented in previous progresses on the excellent work of Biesalski, Mayer, and Henze, along these lines. It is evident also that quicker and surer return of function is accomplished if the transplanted muscle has the same general motor purpose as the one whose place it is being asked to fill. Thus, an active flexor more perfectly supplies the place of a paralyzed flexor. But it is by no means impossible to reeducate flexors to become extensors, as in the brilliant results of tendon transplantation for wrist drop in musculo-spiral paralysis and in the conversion of the plantar flexing peroneals into dorsal flexors of the foot. Early function is also being increasingly appreciated as an important factor in success, and bony attachment of the transplanted tendon is another factor, unless, as Lorenz and Perthes advocate, we shall find that the tendon of the paralyzed muscle may be employed to transmit the pull of the transplanted muscle. The outcome of Santer's and Van Assen's cases of transplantation of the external oblique muscle to regain abduction and stability of the hip is encouraging enough to warrant a further trial of the procedure by other surgeons. We have yet to see a really satisfactory result from the transplantation of any muscle or group of muscles for paralysis of the deltoid and the other shoulder abductors, and we believe arthrodesis offers the best present hope of improving function. In calcaneo valgus caution seems to be necessary in relation to utilizing both the peroneus tertius and the extensor hallucis, as well as the peroneus brevis, unless the gastrocnemius is well developed and very active. In some cases a calcaneus has developed, especially if the Achilles tendon has been divided, which usually leaves a still more weakened muscle. Where the gastrocnemius is weak, the peronei, tertius or brevis, might well be put into the Achilles tendon instead of bringing them forward to the inner side of the foot. A strong gastrocnemius is a most important factor. Without this support fatigue comes quickly. The only brief which we hold against Dunn's operation for calcaneo valgus is that the removal of wedges of bone which he advises may, in children's feet, affect unfavorably the growth of the foot. An adult with one foot much smaller than the other always has the serious problem of shoeing to face. This problem is the more serious in these days of ready-made shoes, and the scarcity and prohibitive prices of the individual boot maker.]

Lovett<sup>13</sup> describes what he terms the tripod method of walking, by which patients with complete paralysis of the lower limbs may be gotten on their feet. They lean forward on their crutches, which are placed well in advance of their feet, and by alternately drawing their feet forward toward the crutch points, and advancing first one crutch, then

the other, or, when good balance is acquired, both crutches at the same time, they are able to progress by successive shifts of the center of gravity.

*Spastic Paralysis.*—Ansart,<sup>59</sup> in Spain, as well as Bucholz, Gill and Hatt, in America, advocate Stoffel's operation of partial resection of the peripheral nerves for spastic paralysis as the logical treatment in many cases. His results in four cases have been excellent, based on extensive experiments on dogs. The tendons which in long standing cases have become actually shortened should be divided as well.

Abrahamsen<sup>60</sup> reports a case of localized spastic paraplegia following a stab wound of the neck. Half of each peripheral nerve branch innervating the spastic muscles was resected, and the spastic phenomena subsided almost completely.

[Ed. Note.—This case of Abrahamson's and a somewhat similar and equally brilliant case of Hatt's<sup>61</sup> seem to us to open up an extremely suggestive lead toward the relief of spastic conditions arising from direct injuries to the cord from penetrating wounds, fractures, and hematomyelitis, and to the partial paralyses of a spastic nature following cerebral hemorrhage in adults. This latter class of patients often live many long and weary years after their first apoplectic attack. The operation on the peripheral nerves is not a serious one. In many cases it may be performed under local anesthesia, and it is capable, evidently, of affording great relief and enormously improving locomotion.]

*Obstetric Paralysis (Erb's Palsy).*—Sever,<sup>62</sup> after a very careful study of a large series of personally observed cases, believes that no operation should be performed until massage and carefully studied exercises have been continued for several years, and all possible functional improvement and muscle stretching have been gained. He considers that the operations on the brachial plexus have been, by and large, very unsatisfactory. His operation, similar to that of Fairbank, of dividing the tendons of the pectoralis major and the subscapularis, has resulted in full, active outward rotation, and nearly normal abduction and supination. The after-care, consisting of retention in an abduction splint for six months, removed for massage and exercise, is of great importance. The results are best where the deltoid and supraspinatus are not paralyzed, and worst in the lower arm type. The latter type of case he believes justifies an early exploration of the brachial plexus.

Taylor<sup>63</sup> still believes in operating on the brachial plexus in most cases of obstetric paralysis, since recoveries as a whole have been so

59. Ansart: *Archiv. Españ. de Ped.*, April, 1919.

60. Abrahamsen: *Ugesk. f. Læger*, Aug. 7, 1919.

61. Hatt: *Boston M. & S. J.*, June, 1921.

62. Sever: *Canad. M. A. J.*, Feb., 1920.

63. Taylor, A. S.: *Surg., Gynec., and Obst.*, May, 1920.

unsatisfactory. He thinks the best time for this operation is at about three months. The procedure is an incision at the base of the neck through the skin, platysma and underlying fat, exposing the plexus. He considers it a simple and not dangerous operation, even if no damage is found. In a series of seventy cases his results were generally a great improvement, much more satisfactory than in his series of 130 unoperated cases.

Boorstein <sup>64</sup> agrees with Sever that only the lower arm types require plexus operation if the cases are seen early, and treatment by support, massage, and exercises, but not electricity, is continuous. In four pathologic specimens the usual lesion was shown to be a tear of the nerve sheath, with hemorrhage and cicatrices at the junction of the fifth and sixth cervical nerves.

Stomann <sup>65</sup> also rejects the theories of Lange of a distasia, of Küstner of an epiphyseal separation, and of Turner Thomas of a dislocation, considering the lesion of the cervical plexus to be the correct explanation of the symptoms. He is in agreement with Sever both as to cause and as to methods of treatment.

Platt <sup>66</sup> has written a valuably judicious article on birth paralysis, based on a thorough review of the literature and a personal study of twenty-three cases. He concludes that the evidence all points to a supra-clavicular lesion of the brachial plexus, although he admits that great force is necessary to produce this experimentally. The clinical evidence, strongly suggesting a primary shoulder-joint lesion, is of a purely negative type. Actual confirmation of a lesion of the capsule is lacking, as is evidence of epiphyseal separation.

[Ed. Note.—The consensus of clinical and experimental evidence, and especially the report of the pathologic specimens of Boorstein, seems to point to a lesion of the plexus as the important etiologic factor in birth palsy and to justify Sever in his strong championing of Erb's original theory. We are not convinced, however, that operation on the plexus, except in the more severe lower arm types, has yielded any better results than more conservative measures. Until more conclusive evidence can be brought forward of its value, we believe it should be reserved for the class of more severe cases whose helplessness at least makes the danger of doing harm a negligible one.]

*Hysterical Paralysis.*—Froment <sup>67</sup> discusses with conviction the treatment of hysterical paralysis, making a point of the importance of prompt treatment and quick recognition from a general sizing up of

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64. Boorstein: Med. Rec., Nov. 15, 1919.

65. Stomann: Hospitalstid., 1917, No. 30.

66. Platt: J. Orthop. Surg., May, 1920.

67. Froment: Lyon méd., Jan., 1920.

the syndrome rather than an exhaustive search for typical stigmata. The condition is often completely curable in a few hours if the physician possesses an inflexible will, patience, kindness, energy, absolute confidence in the outcome, and skill in detecting some movement in the paralyzed limb, demonstrating this to the patient. It is useless to argue or reason with the patient, but the session should be continued until some striking result has been obtained.

#### CONGENITAL DEFORMITIES AND DISEASES

*Cervical Ribs.*—Honeij<sup>68</sup> has contributed a very excellent review of the embryology and morphology of cervical ribs. He considers the following the most important symptoms: (1) Local: tumor, pain on pressure, bruit, etc. (2) Nervous: these are more frequent than vascular signs of pressure. (3) Vascular: pulsations, ischemic edema, thrombosis, aneurism, gangrene. (4) Muscular: atrophy, loss of power, quick fatigue, dysphagia, scoliosis. He points out the fact that many persons who show the presence of cervical ribs have none of these symptoms and that many of these symptoms may occur in the absence of true cervical ribs. However, if careful examination is made, many of these latter will be found to possess anomalies of the transverse processes which cause pressure at the typical place, between the seventh cervical and the first dorsal. It all depends upon the amount of space between the processes or ribs, and scoliosis or faulty posture may determine this space. Although the condition is usually bilateral, the symptoms are, in 95 per cent., unilateral and more common on the left. In his series there were nine true cervical ribs, twelve rudimentary cervical ribs, seventeen tubercle formations and abnormalities, and thirteen thoracic rib abnormalities.

Rovsing<sup>69</sup> reports four cases of removal of cervical ribs through a posterior incision parallel to the spinous processes and 2 cm. distant, laterally placed. The rhomboids and trapezius muscles were divided, the splenius retracted. The cervical rib was now easily isolated and removed after cutting it with a rib guillotine. There is practically no hemorrhage by this route, but its great advantage is that it avoids all danger of injuring vessels or nerves. The symptoms in his cases had come on when the patients had taken up wage-earning work, and varied from the common neuralgias, scolioses, and vasomotor disturbances, to aneurysm of the subclavian artery.

Meucci<sup>70</sup> finds thirty-five cases of operations for cervical ribs and adds another successful case, in which the rib was removed through a posterior incision along the trapezius.

68. Honeij: Surg., Gynec., and Obst., May, 1920.

69. Rovsing: Hospitalstid., May 28, 1919.

70. Meucci: Riforma med., Oct. 11, 1919.

*Congenital Dislocation of the Shoulder.*—Schmieden<sup>71</sup> reports excellent results in congenital dislocation of the shoulder by a modified operative procedure devised originally by Joseph. Instead of incising the joint, a hole is drilled through the neck, head, and acromion, and a strip of fascia pulled through and fastened in place.

*Congenital Dislocation of the Hip.*—Calot,<sup>72</sup> after a roentgenologic study of "several thousand" cases of congenital dislocation of the hip, states that the primitive acetabulum in very young children belongs much more to the ischium than to the ilium. This fact, he concludes, should influence the position in which the limb is placed after reduction, in order to secure the deepest and most stable socket. The first cast, according to Calot, should be applied in the horizontal position with the thigh flexed to the extreme, i.e., 135 degrees. The second cast, applied in from three to four months, is adjusted in right-angled flexion, and the third, three or four months later, in 45 degrees of flexion.

Tubby<sup>73</sup> asserts that in congenital dislocation of the hip the outward displacement of the iliopsoas muscle and tendon brings it closely beneath the anterior inferior spine. As it then winds outward and backward, it compresses the middle of the hip joint capsule and causes the hour-glass constriction so commonly appreciated in children more than 4 years of age. This constriction increases with the thickening of the tendon as age advances, and the anterior wall of the capsule is folded inward and backward, actually obscuring, like a curtain, the entrance into the acetabulum. In older cases, Tubby, by open operation, makes a crucial incision into this capsule, dividing the constriction and the iliopsoas tendon. He states that now, with a little traction, the head of the femur slips easily into the acetabulum, and that by this procedure he has been able to advance the age for successful reduction of congenital hips from 7 years onward. His last patient was a girl of 15. The limb is put up in the fully abducted position in plaster.

Lorenz and von Baeyer<sup>74</sup> think they have found a solution for old cases of congenital dislocation of the hip in which replacement of the head is out of the question. This operative solution consists of an oblique subtrochanteric osteotomy. The end of the shaft is pushed inward by abduction of the thigh; then pressed upward toward the acetabulum. Gradual consolidation takes place, Trendelenburg's symptom disappears, and greater stability in walking is secured, the head and neck overhanging the upper end of the shaft. The method is applicable chiefly to unilateral cases, since the subsequent limitation of motion is usually too great for double lesions.

71. Schmieden: München. med. Wchnschr., 1919, No. 20.

72. Calot: Bull. Acad. de méd., April 20, 1920.

73. Tubby: Lancet, Dec. 20, 1919.

74. Lorenz and von Baeyer: Wien. klin. Wchnschr., 1919, No. 41.

We note, only to express our adverse opinion as to the rationale of, Frauenthal's<sup>75</sup> rather sensational procedure, announced as a revolution in the treatment of congenital dislocation of the hip in young children. He reports that he has reduced congenital dislocation in twenty-five cases and allowed the children to walk immediately, without any plaster. It is possible that an occasional hip may remain in place, but we do not believe that an impartial study of the results is likely to lead to any very general practice of the method.

*Spina Bifida.*—Vaglio<sup>76</sup> has observed twenty-three cases of spina bifida in the children's clinic of Naples in the last six years. In 52 per cent. there were other malformations, and inherited syphilis was present in 39 per cent. This large percentage of syphilis suggests to Vaglio the wisdom of antispecific treatment before operation. This operation, he believes, should not be performed in the first few months of life.

*Polydactylism.*—The University of Christiania has founded an institute for research in heredity, and its first official paper is by Bonnvies<sup>77</sup> on polydactylous families in Norway. He found in a certain district a number of families with a supernumerary little finger, perfect or rudimentary, on the right hand, and sometimes on the left as well. The families have intermarried often, and the anomaly was traced back to a common ancestor about 1660. Forty of his descendants, in six families, have been known to be polydactylous, and in two apparently normal members transmitting the deformity examination revealed a rudimentary knob at the base of the little finger.

Arps<sup>78</sup> reports a carefully worked up case of a negro who had a small but well formed sixth digit at the knuckle of both little fingers. The father had the same condition, the brothers and sisters also, and the children of the negro's oldest and youngest sisters. The father had the extra digits removed, but it has been necessary to trim them off again, as they continued to grow.

*Clubbed Finger.*—Weber,<sup>79</sup> believing that the "clubbing" of the fingers is so generally looked upon as an evidence of disease of the thoracic vertebrae, calls attention to the fact that this phenomenon may occur in healthy persons as a familial peculiarity. He reports three healthy brothers, two of them twins, who had clubbed fingers, and a fourth male with clubbing of fingers and toes. He says that G. West

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75. Frauenthal, H. W.: Revolution in Treatment of Congenital Dislocation of Hip in Young Children, J. A. M. A. **74**:80 (Jan. 10) 1920.

76. Vaglio: *Pediatrics*, Jan., 1920.

77. Bonnvies: *Norsk Mag. f. Laegevidensk.*, July, 1919.

78. Arps, G. F.: Polydactylism and Phenomenon of Regeneration, J. A. M. A. **74**:873 (March 27) 1920.

79. Weber, G. F.: *British M. J.*, Sept. 20, 1919.

of London has seen three similar cases and that von Eiselsberg of Vienna, reporting similar cases, suggests that the condition is of a lymphangiomatous nature.

*Congenital Variations in the Fifth Lumbar Vertebra.*—Nové-Josserand<sup>80</sup> has encountered five cases in which the complaint of pain in the lumbosacral region was associated with malformations of the fifth lumbar vertebra and overdevelopment of the transverse processes, crowding the fifth lumbar nerve. The unilateral cases had appropriate unilateral pain. He considers resection of the transverse process a rational procedure.

Richards<sup>81</sup> has examined the roentgenograms of the lumbar spine taken for genito-urinary conditions and compared them with those referred for back pain. The former show a much smaller percentage of anatomic variations than do the orthopedic cases, only 10 per cent. of the latter failing to show abnormalities.

#### POSTURE

Brown,<sup>82</sup> by a fortunate association with a broadminded professor of hygiene in a great university, has had an exceptional opportunity to study the association of poor bodily mechanics and poor health. It is probably true that the orthopedic surgeon does not often enough study his patients from the purely medical point of view, and the converse of this is certainly equally true of the internist. We do not recognize the relation of bodily mechanics to physical and mental health. Brown's plea for efficient mechanical use of trunk, legs, and feet, is based on solid argument derived from this study of thousands of supposedly fairly healthy undergraduate students. The methods of developing proper posture may differ, but we shall all agree that childhood is the time to make correct posture habitual, not only for better health in childhood, but for excellent health in later life.

Ansell<sup>83</sup> recognizes four groups of bodily physique and shows that each group presents certain characteristic proportional dimensions of thorax and abdomen, and also definite types of visceral form, position, and tonus, which are fairly constant in each. Group 1. Hypersthenic habitus: Heavy and broad type; hypertonic stomach, small and transversely placed; emptying time, three to three and one-half hours. No intestine in pelvis, but colonic flexures high. Group 2. Sthenic habitus: Physical qualities are similar to those of Group 1, but the visceral characteristics tend toward the pototic type. The stomach is more vertical

80. Nové-Josserand: Lyon chir., Nov.-Dec., 1919.

81. Richards: Am. J. Roentgenol., Sept., 1919.

82. Brown: Boston M. & S. J., June 24, 1920.

83. Ansell: Am. J. Roentgenol., Sept., 1919.

and tubular; emptying time from three and one-half to four and one-half hours. The intestine is lower; as are the colon and flexures. Slight stasis at twenty-four hours. Group 3. Hyposthenic habitus: frail and slender physique is noted; stomach fishhook type, relaxed and low, emptying time five to six hours; small intestine mostly in pelvis, and transverse colon resting on pelvic organs. This is the most frequent type seen. Group 4. Asthenic habitus: All the characteristics of Group 3 are present, but are more marked. The stomach is markedly elongated and dilated, and a greater curvature is often seen in the true pelvis. The emptying time is slow. All the intestine and the colon are in the pelvis. Forty-eight hours residue is common, and seventy-two hours frequent.

*Pressure Symptoms from Normal Ribs.*—In the *Journal of the American Medical Association* attention has been called<sup>84</sup> to the fact that symptoms due to pressure on motor, sensory, or sympathetic fibers of the lower trunk of the brachial plexus may occur not only from abnormal cervical ribs, but also from a normal first rib. He called attention to the article of Sir William Wheeler,<sup>85</sup> reporting such a case, in a previous Progress, and since then Stopford and Telford<sup>86</sup> have reported ten other cases of this type. Eight of these they call idiopathic and two traumatic. In all but one objective, sensory disturbance was greater than loss of epicritic. Stopford has previously called attention to the fact that he considers this phenomenon characteristic of nerve compression. Trophic and vasomotor changes were constant, the most frequent being hypothermia, pallor or cyanosis, and trophic sores affecting the little and ring fingers, and more rarely the inner border of the forearm. It should be remembered that weakness of the hand and subjective sensory manifestations may be the result of compression of the lower trunk of the brachial plexus by a normal first rib, as well as by a supernumerary costal element.

#### NEOPLASMS

Lozano<sup>87</sup> describes his experiences with sarcoma of the long bones, confirming the opinion of other observers that those which originate in the periosteum are by far the most malignant. In the myelogenous variety the disease remains long confined to the bone and there is less danger of metastasis. A bone graft may well be attempted after excision of the tumor mass.

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84. The Production of Pressure Symptoms by Normal Ribs, *Current Comment*, J. A. M. A. **74**:110 (Jan, 10) 1920.

85. Wheeler: *Dublin M. J.*, April, 1920.

86. Stopford and Telford: *British J. Surg.*, Oct., 1919.

87. Lozano: *Plus Ultra*, Madrid, Feb., 1919.



Martinez<sup>88</sup> reports thirteen cases of extensive sarcoma of the long bones, 80 per cent. were in males, and all but two of the patients were between 20 and 40 years. In almost all the cases there was a history of a contusion at the seat of the tumor. Five were in the upper end of the femur; three in the lower end of the femur, and three in the upper end of the humerus; one was in the lower end of the humerus; and one in the middle of the tibia. He believes that amputation or disarticulation offers the only hope in all rapidly growing sarcomas involving the soft parts, but, if the soft parts are not involved, resection of the mass has yielded as satisfactory results as amputation.

Coley's<sup>89</sup> study of 250 cases of bone sarcoma is a most important contribution to the literature of the subject. He believes that an early and accurate diagnosis is of greatest importance, and states that deep, steadily increasing, boring pain is often the earliest symptom, and the most persistent. He considers early diagnosis so important that he advises exploration in all doubtful cases in order to disclose the possible presence of a neoplasm, and, on discovery, to determine its histologic nature. He minimizes the risk of metastases from this procedure. He states that as a confirmatory method the roentgen ray makes the diagnosis fairly certain. Coley endorses the stand of Bloodgood and Platou that the giant-cell tumors are relatively nonmalignant. He advises conservative surgery not only in the treatment of this form and osteitis fibrosa, but also in true sarcomas of the long bones, both of central and sometimes of periosteal origin. Coley admits that in many cases it is difficult or impossible to determine whether the tumor in question is benign or malignant. In his own list of forty cases, in which the diagnosis of giant-cell tumor was made by leading pathologists, eight patients died of metastases. That the myelogenous or mixed-cell sarcomas, particularly of the lower end of the femur, are for the most part malignant is shown by the statistics of Bruns' clinic. In eleven of the thirty-three cases in which amputation was performed, one patient died of the operation, but of the remainder only two were known to be well after the three-year period. Coley concludes that benign giant-cell tumor of the lower end of the femur is very rare. He still believes that the routine treatment of all bone tumors with the mixed toxins of erysipelas and prodigiosus offers the best chance of cure, combined in certain cases with radium. He attempts to contrast his own figures with those of a symposium on sarcoma of the long bones before the Royal Society of London in 1912. A study of sixty-one cases of sarcoma, at St. Bartholemew's Hospital, occurring in ten years, all of which were treated by amputation, revealed that none of the twenty-

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88. Martinez: *Repert. d. med. y. cirug.*, Aug., 1919.

89. Coley: *Ann. Surg.*, Dec., 1919.

five patients having periosteal sarcoma of the femur was alive at the end of three years, none of the eight having periosteal sarcoma of the humerus was alive at the end of three years, but one of two having periosteal sarcoma of the radius, and one of eleven having periosteal sarcoma of the tibia. Two patients of four having myeloid sarcoma of the femur were alive at the end of three years, and one of three having myeloid sarcoma of the tibia, making only five patients living of sixty-one cases of all forms of the disease. At St. Thomas Hospital there was the same sad story. Twenty-eight patients having periosteal sarcoma were all dead in three years and only five patients having myeloid sarcoma survived, and these cases were all of the giant-cell type. Of Coley's 117 femur cases of all sorts of sarcoma, fifteen patients who underwent amputation were alive at the end of three years, and six who did not, three of whom he says had periosteal sarcoma. In eight of his forty tibial cases, the patient survived three years, four with amputation, and four without. In none of his eight fibula cases did the patients survive three years, and in only two of his fifty cases of lesion of the humerus, and in neither of these was amputation undergone. Of his twelve radius cases, one patient lived three years after amputation, and three lived three years without amputation. Of six ulna cases, one patient survived after amputation, and none without. Of eleven clavicle cases, two patients recovered with total excision and the use of mixed toxins. In a total of 250 cases thirty-five patients were well at the end of three years, but five of these had recurrence which proved fatal at a later date. Coley's percentage of three-year cures of all forms is thus 14 per cent., St. Bartholomew's 8.2 per cent., and St. Thomas's 11.1 per cent.; surely not a very wide variation.

Poletini<sup>90</sup> reports three cases of solitary bone cyst, two in children and one in a young adult. The clinical course and the appearance at operation were the same, but the pathologic report on the adult case was sarcoma. The cure was complete in all.

[Ed. Note.—It is much to be hoped that the recently organized commission for the study of this subject, fathered by the American College of Surgeons, and originated by Dr. E. A. Codman, will serve to clarify our conceptions of both the rational treatment of these varieties of sarcoma of the long bones, and also to standardize the nomenclature. At the present moment there is no standard terminology even among the pathologists themselves, nor even any agreement as to actual types. Until these types can be constantly recognized microscopically and called by the same names, the likelihood of collecting valuable clinical data or standardizing treatment must be slight.]

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90. Poletini: Policlinico, July, 1919.

*Chondromas.*—Meyerding<sup>91</sup> states that the problems of diagnosis of chondromas are difficult even with good roentgenograms. He believes that conservative surgery and local curettage is the method of treatment even when trauma has caused a rapid extension of the growth. He states that they rarely recur and only in exceptional cases become malignant.

[Ed. Note.—The Editors have encountered difficulty in local eradication of these growths, though they have not known of metastases. They have found that local recurrence is not rare, even after apparently very thorough surgery, and they have known of several cases in which amputation alone seemed to control the further growth of the tumor.]

*Metastatic Carcinoma in Bone.*—Moore<sup>92</sup> has made a roentgenologic study of metastatic carcinoma of the bones. He accepts the two types of von Recklinghausen: osteoclastic and osteoplastic. The osteoclastic appears in the roentgenogram as increased density of bone, and with a honeycombed appearance; the osteoplastic as irregularly increased density, chalky in type, without cortical or periosteal thickening. The osteoclastic occurs more often as a metastasis from carcinoma of the breast and the osteoplastic as a metastasis from the prostate. In sixty-five cases at the Mayo Clinic, the breast was primary in thirteen, the prostate in eleven, and the kidney in seven. Metastasis in the spine occurred in twenty-two cases, in the pelvis in eleven, in the femur in nine, in the ribs and the humerus in six, in the radius and skull in three, in the tibia in two, and in the clavicle, sternum, and hand, in one. There was spontaneous fracture in six of the sixty-five cases.

Pfahler<sup>93</sup> reports four cases of metastatic carcinoma of the spine with extensive involvement elsewhere, in which intensive roentgen-ray treatment undoubtedly greatly mitigated the severity of the disease.

*Osteitis Fibrosa.*—Slesinger<sup>94</sup> believes that osteitis fibrosa is a disease of the epiphyseal period, different from von Recklinghausen's disease, which occurs late in life. Osteitis fibrosa consists of a metastatic transformation of bone marrow into fibrous tissue, and results from chronic inflammation of unknown origin in the endosteum. The predilection is for the juxta-epiphyseal region, and trauma probably plays no part in the etiology, though it may call attention to the existence of the disease. Sex has no influence. The age is about 12. He records forty-six cases of the femur, twenty-seven of the humerus, and twenty-seven of the tibia. The small or large cysts contain clear or light brown fluid, not under tension. The surrounding

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91. Meyerding: J. Orthop. Surg., Feb., 1920.

92. Moore: Am. J. Roentgenol., Dec., 1919.

93. Pfahler: Surg., Gynec., and Obst., Sept., 1919.

94. Slesinger: Lancet, Nov. 15, 1919.

bone is thinned, with no evidence of new deposit. If there is no cavity, the bone is filled with fairly firm fibrous tissue, with fluid in the meshes. The symptoms are usually only those of the complications, such as fracture and deformities. The treatment is purely local; curetting the bone and correcting the deformity. The bleeding may be troublesome; and he reports two deaths.

*Myositis Ossificans*.—Hammer<sup>95</sup> has studied twenty cases of myositis ossificans and believes that it develops from a myogenic inflammation. All of the cases had a more or less traumatic origin. The roentgenogram reveals two different groups, the first group representing early cases in the young, and revealing a cloudy indistinct series of spots or striations; and the second group of older cases revealing more sharply limited, dense cortical stripes, with spongiosa as well. The bones themselves appear unchanged.

#### OSTEOMYELITIS

Rost<sup>96</sup> discusses the question as to whether it is always necessary to open the bone in cases of subperiosteal abscess. His material is from the surgical clinic of Heidelberg and comprises 266 cases, seen in the last twenty years, in which it has been possible to compare different forms of treatment under different chiefs of service. He concludes from the record of these cases that the opening of the bone is more dangerous than the drainage of the abscess. The mortality has been higher and the complications more frequent. He believes this is because more tissue is opened and infected. Often a section has shown that even when pus is seen to exude from the haversian canals, the cortex alone was infected, the marrow being still normal.

Two articles by Grégoire<sup>97</sup> are also interesting on the vaccine treatment of osteomyelitis. He refers to acute staphylococcus infection, reporting nine cases in infants and older children which, he says, 'upset all preconceived ideas as to treatment. He has used a regional stock vaccine and an autogenous vaccine from the puncture of the abscess; and he says that the effect of the stock vaccine seems almost, if not quite, as good. For the initial dose he injects 0.1 c.c., representing 200,000,000 of the dead micro-organisms. From two to nine subsequent injections were given, depending upon the reaction of the heart and kidneys, of never more than 400,000,000. The pulse runs up in from eight to ten hours, remaining high for from two to four days, and a transient slight albuminuria may be expected. He does not give a second injection until the pulse has returned to normal. He considers

95. Hammer: Fortschr. a. d. Geb. d. Röntgenstrahlen **25**:14, 1917.

96. Rost: München. med. Wchnschr., 1920, No. 52, p. 1492.

97. Grégoire: Paris méd., Oct. 11, 1919; Bull. méd., Jan. 17, 1920.

the treatment of no avail in cases in which septicemia is already established, and in two cases of this sort in his series, both patients died. He would not persist with the vaccine alone if the fever did not show signs of abating in forty-eight hours. However, even in the presence of a large abscess, he has only punctured to relieve tension, and has not opened and drained, and these swellings have entirely subsided. In six of his cases the children began to feel better in from twenty-four to forty-eight hours, the pain subsided, and within fifteen, twenty, thirty, or forty days, the child was using its limb and there has been no tendency to exostoses or sequestration.

Vignard<sup>98</sup> points out the extreme difficulty in acute osteomyelitis of accurately localizing the area of infection, emphasizing the great danger of opening sound tissue in an operative search. He has found himself often in doubt as to the wisest procedure, balancing the risk of the spread of the disease by conservative measures, and the risk of infection of healthy tissue and of inducing complications by surgical procedures. Impressed by his cases more with the danger of the latter than that of the former, he has compromised by causing a large turpentine aseptic fixation abscess over the seat of pain and swelling. His results have compelled him to adopt this procedure as a routine treatment in all cases of osteomyelitis. He reports several severe cases in which the prompt inducing of this abscess was followed by an entire subsidence of the process, although the fever kept high for a day or two. In the case of a boy of 14, with complaint of pain in the leg, followed by delirium and a temperature of 40 C. for three days, and in which puncture of the hip joint released from 3 to 4 c.c. of turbid fluid, the process began to subside after the induction of the turpentine abscess (3 cm. in diameter), and although the temperature remained high for a day or two, complete cure resulted.

[Ed. Note.—We report these three articles by apparently careful observers, who have all seemingly become convinced that too extensive surgery has been advised and practiced in acute osteomyelitis, especially in children. At the Toronto (1920) meeting of the American Orthopedic Association, Colonel Starr, a surgeon of wide experience and unusual judgment, warned against too radical surgery in cases of acute epiphysitis in children, and took much the same position as Rost in advising strongly against opening into the medullary cavity, unless there existed very strong proof that it was already infected. We have also witnessed not a few disasters from too radical opening of bone in acute osteomyelitis; and while prompt action and fearless procedures are as necessary as ever in certain cases, we believe that these articles should cause us to pause.]

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98. Vignard: *Presse méd.*, Sept., 1919.

Gallie's<sup>99</sup> conclusions as to bone sepsis following his extensive military experience with acute and chronic osteomyelitis are enlightening and probably sound. The principles which he has outlined are as follows: (1) The periosteum is the medium by which blood vessels are distributed to the shafts of bones. Reflection of the membrane produces superficial necrosis and should never be done when sepsis is present or feared. (2) The periosteum, as reflected in an ordinary surgical operation, is merely a fibrous tissue membrane and is not osteogenetic. It should, therefore, never be relied on to restore the shaft after resection. (3) Mild chronic septic infection is a strong stimulant of inflammatory osteogenesis. It causes widespread osteoporosis, increased vascularity, and abundant callus formation. This is the state in which cavities are most apt to heal, and fractures to unite, unless prevented by some definite condition such as the presence of sequestrums or the existence of too large a gap. (4) When the irritation subsides or disappears, this rarefying osteitis gives place to an intense sclerosis which is very inimical to the healing of cavities or the union of fractures. (5) Treatment should therefore take advantage of the pathologic condition which is present at the time the sequestrums have separated, and aim at a complete cure before osteosclerosis has supervened. It should consist of the complete excision of the scar and sinus, and the wide removal of the walls of the cavity, for the purpose of thorough evacuation of sequestrums and unhealthy granulation tissue. All irregularities and pockets must be obliterated and, when possible, the depth of the cavity should be reduced by allowing the soft structures to fall into it. Pedunculated muscle or fascia flaps are of great assistance in promoting rapid healing. Finally, wide-open drainage must be provided so that the cavity can heal from the bottom, without depending on the dangerous alternative of a narrow sinus. (6) Non-union in compound fractures, uncomplicated by great loss of bone, is rare. When present, the fact that the wound is septic is no contra-indication to active treatment of the fracture, as well as of the osteomyelitis. Gratifying results may be anticipated from thorough freshening of the ends and the adjusting of the fragments, provided efficient drainage is secured. (7) The best time to correct malunion in septic cases is at the time of operation for the cure of the disease in the bone.

#### NONTUBERCULOUS JOINT DISEASES, ETC.

*Osteochondritis Juvenilis*.—Kreuter,<sup>100</sup> from a study of four cases of osteochondritis deformans juvenilis coxae (Legg-Calvé disease) in

99. Gallie: J. Orthop. Surg., Aug., 1919.

100. Kreuter: Zentralbl. f. Chir., 1920, No. 38.

patients who have died of intercurrent diseases, believes the condition to be due to a true deforming arthritis, and that the primarily affected tissue is the articular cartilage. He believes that the secondary bone changes in the head are simply due to function in the presence of the articular disease. He thinks that Perthes' theory that the changes are due to an inflammatory occlusion of the nutritive vessels can no longer be upheld.

Zaaijer,<sup>101</sup> in an article on anomalies of the head and neck of the femur of the above type, says that the final outcome may be a perfect joint, or like the end-result of a severe deforming arthritis. He considers that the condition is akin to the epiphysitis (Osgood-Schlatter) of the tibial tubercle.

Scheuermann<sup>102</sup> has been studying 105 cases of what he calls *kyphosis dorsalis juvenilis*. Eighty-eight per cent. were in boys from 10 to 19. In all there was a history of hard work, and he considers the condition in the spine to be analogous to the *osteocondritis juvenilis* of the hip (Legg-Calvé).

*"Muscular Rheumatism."*—Schmidt,<sup>103</sup> and also Gaugele,<sup>104</sup> has made a study of muscular rheumatism or neuralgias, being both victims of the disease themselves. Their observations of their own symptoms, and the affection in other patients, lead them to believe that there is no true involvement of the muscles themselves, but of the sensory nerves only of the muscles, bones, and other subcutaneous tissues. Rest, analgesis, heliotherapy, are the rational treatment, and any but the most careful and gentle massage is contra-indicated.

*Chronic Nontuberculous Arthritis—Focal Infection.*—Gibney's<sup>105</sup> conclusions as to the relation of focal infection to the arthritides are the result of wide and sound experience: (1) A focus of infection should be diligently sought for in every case of arthritis, where tuberculosis, malignancy or trauma are not self-evident, as causes, or at least as controlling factors. (2) A monarticular arthritis demands the same painstaking investigation as does a polyarticular, for one can never tell when the former may merge into the latter. (3) While the finding of a focus and the proper handling of the same may be followed sooner or later by relief, one cannot assume that the infection is at an end. (4) The arrest of the infection does not mean that the exudates into the joint will disappear unless orthopedic measures are

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101. Zaaijer: *Nederlandsch Tijdschr. v. Geneesk.*, Feb. 14, 1920.

102. Scheuermann: *Ugesk. f. Laeger*, March 18, 1920.

103. Schmidt: *Monograph*.

104. Gaugele: *München. med. Wchnschr.*, 1917, No. 37.

105. Gibney: *J. Orthop. Surg.*, Feb., 1920.

employed to bring about resolution and restoration of function. (5) The finding of one focus does not mean that this is the only focus bearing on the case. It must be remembered that many organs are exposed to bacteria of a pus-producing nature and that a careful study of these organs should be the rule.

Pemberton and Tompkins,<sup>106</sup> studying 400 cases of arthritis in soldiers, found that in 107 cases there was an apparent absence of surgical foci. Two hundred and ninety-three had demonstrable surgical foci. Of these, 208 showed foci in the tonsils, seventy-eight showed both dental and tonsillar foci, and thirty-eight showed some other combination of surgical foci. One hundred and thirty-four were positive for genito-urinary foci.

Hay,<sup>107</sup> writing on the treatment of septic arthritis by autogenous vaccines, prepared from the Cornellan-King diplococcus, asserts that nearly every case of septic arthritis gives a definite history of tonsillitis, mild or severe, at some previous time, and that cases of septic arthritis commonly show a purplish hue on the mucous membranes of the nose and the anterior pillars, which is practically diagnostic. He believes that the vaccines should be used as a routine, and considers them an efficient remedy.

Byfield,<sup>108</sup> from a study of a series of cases of "arthritis deformans" (Still's disease) in children, has become convinced that a chronic infection of the tonsils, adenoids, and accessory sinuses is the responsible etiologic factor.

Nordlund<sup>109</sup> has carefully tabulated the details of thirty cases in which tonsillectomy had been performed to prevent recurring attacks of polyarthritis or hemorrhagic nephritis. He states that this effect was realized in the great majority of cases whether the tonsillectomy was done during an acute attack or during an interval.

Epstein<sup>110</sup> believes that focal infection is the common cause of painful heel, the three commonest foci of infection being the tonsils, the teeth, and the genito-urinary tract.

*Meningococcus Arthritis.*—Herrick and Parkhurst<sup>111</sup> report on the occurrence of arthritis among 321 cases of epidemic meningitis. There were three types of arthritis: (1) An acute polyarthritis occurring as an early or initial symptom of the disease, never after the third day. Pain and tenderness are great, effusion is slight. There were twelve

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106. Pemberton, R., and Tompkins, E. H.: Arch. Int. Med. **25**:241 (March 15) 1920.

107. Hay: Ohio State M. J., Nov., 1919.

108. Byfield, A. H.: Am. J. Dis. Child, **19**:87 (Feb.) 1920.

109. Nordlund: Hygiea, June 16, 1919.

110. Epstein: Med. Rec., Aug. 21, 1919.

111. Herrick and Parkhurst: Am. J. M. Sc., Oct., 1919.



cases; eight patients recovered, four died. (2) Later type, occurring about fifth day, usually monarticular. Pain and tenderness are slight, effusion is great. There were sixteen cases; fourteen patients recovered, two died. (3) Serum arthritis after injection of specific serum.

Nobécourt and Paraf<sup>112</sup> have encountered a case of obscure arthritis in an infant, in which lumbar puncture revealed the presence of an unsuspected meningococcus, and puncture revealed an abscess deep in the brain. They believe the case instructive and suggestive. There were no symptoms of a meningitis.

*Scarlet Fever Arthritis.*—Mayet and Laval<sup>113</sup> state that the cervical vertebrae are frequently involved in a suppurating arthritis following scarlet fever, which may easily be mistaken for Pott's disease.

*Gonorrheal Arthritis.*—Dufour<sup>114</sup> calls attention to the fact that it is difficult clinically to distinguish a gonorrheal arthritis from an acute articular rheumatism. He has noticed that in gonorrheal arthritis, intra-articular end-bone pressure causes pain, but it does not cause pain in acute articular rheumatism. The early changes in the articular ends often seen in the roentgenograms in gonorrheal joints, but absent in rheumatic joints, explain this diagnostic sensitiveness.

Débré and Paraf,<sup>115</sup> impressed with the effect of local serotherapy in meningitis, injected gonococci directly into the anterior chamber of rabbits' eyes, following this with direct injection of antigenococcus serum. The prompt cures resulting induced them to try injections of antigenococcus serum directly into acute gonococcal joints. Of their fourteen patients, all were promptly relieved. They recovered with motion, with the exception of one pregnant woman in bad general condition. The fluid was evacuated and the serum injected every second or third day. The local treatment was supplemented with intramuscular or intravenous injections of the antigenococcus serum.

*Miscellaneous.*—Pemberton's<sup>116</sup> article on chronic arthritis in the *Archives of Internal Medicine*, April, 1920, should be carefully read by everyone interested in the subject. It contains too much detail to be justly abstracted in this report without overbalancing other material, but it is probably the most valuable clinical and laboratory study which has yet appeared. Exposure to cold and dampness was the exciting factor in 58 per cent. of 400 cases in soldiers. There were apparent possible foci of infection in 72 per cent. Although the etiologic importance of focal infection, especially in civil life, is not

112. Nobécourt and Paraf: Arch. de méd. d. enf., May, 1920.

113. Mayet and Laval: Bull. méd., March 13, 1920.

114. Dufour: Bull. et mém. Soc. méd. d. hôp. de Paris, Oct. 31, 1919.

115. Débré and Paraf: Bull. et mém. Soc. méd. d. hôp. de Paris, Oct. 31, 1919.

116. Pemberton: Arch. Int. Med. **25**:351 (April) 1920.

to be minimized, it is clear that the present group showed a considerable independence of it. One hundred and eighty-four patients, or 46 per cent., recovered in the presence of demonstrable surgical foci. This is nearly three times the number which improved after removal of foci. The tonsils were infected in 52 per cent., the teeth in 33.5 per cent., and the genito-urinary tract in only 12.5 per cent. Experience with treatment by a restricted diet as here described corroborates in the present group the conclusions previously published. Such therapy finds additional support in the studies on blood sugar, revealing a difficulty in the utilization of carbohydrates. The several measures of value in arthritis should be combined in their application to the present group more frequently than obtains in the treatment of cases in civil life. The tendency to focus on one measure often results in failure, when the subsequent coincident use of several measures results in benefit. This conclusion of Pemberton's in relation to diet is borne out in Thomson's<sup>117</sup> article on dietetics in chronic arthritis.

Interesting too in this connection is an article by Van Breeman<sup>118</sup> on the arthritic diathesis, written after ten years of study at the Institute for Physical Therapy at Amsterdam. There was in most cases an unmistakable familial and hereditary stamp. He finds that lactic acid, which is rarely found in normal urine, appears in this type after physical exertion and, further, that this is the type which develops rheumatic changes in joints following trauma, especially fractures. He believes that the proper treatment of a large number of so-called functional neuroses depends on the appreciation of this arthritic diathesis.

#### ROENTGENOLOGY

*Lesions of Yaws.*—Maul,<sup>119</sup> in 100 cases of yaws, found twenty which revealed bone and joint lesions. They are described as rarefied areas, oval or elliptical in shape, with their long axes parallel to that of the bone. They may be central or cortical in location. In the chronic lesions there is marked irregularity of the bony outline and there may be interference with the growth of the bone in length and width. Its differentiation from syphilis is made by the absence of any thickening of the cortex or the periosteum. The shaft of the bone was affected in 80 per cent. and the epiphysis in 20 per cent. Ninety per cent. of the patients were less than 30 years of age. All the patients were said to improve slowly under potassium iodid, and arsphenamin was looked on as a specific.

117. Thomson: Practitioner, Aug., 1919.

118. Van Breeman: Nederlandsch Tijdschr. v. Geneesk., Oct. 4, 1919.

119. Maul: Am. J. Roentgenol., Sept., 1919.

*Gout.*—McClure and McCarty<sup>120</sup> have studied the roentgenologic findings in nine cases of gout, taking only those cases in which sodium urate crystals were found in the tophi. The changes which they noted were the following: (1) circular or oval areas of decreased density, called focal areas; (2) proliferative changes, i. e., lipping and spur formations at the margins of the articulations; (3) atrophy, i. e., partial absorption of lime salts from bones; (4) destruction, i. e., irregular areas appearing as complete absorption of bone. They decide that the presence of tophi is the only absolute pathognomonic sign of gout.

The absence of the focal areas of decreased density make the diagnosis of gout improbable, but they are found in from 10 to 12 per cent. of the chronic arthritis cases that are not, clinically, true gout.

#### INJURIES OF JOINTS AND JOINT SURGERY

*Loose Bodies in Joints.*—In a suggestively illustrated article, Colvin<sup>121</sup> discusses the clinical course and pathology of an obscure osteitis causing loose bodies in joints. It is based on four clinical cases of so-called osteochondritis dissecans. The author considers that an infective etiology is more probable than the traumatic theory of Ludloff and Brackett. In his cases the duration of the symptoms and the fact that often no history of trauma could be elicited pointed away from injury as a cause. The pain of an aching character existed for some years before there was any real impairment of function. The final severe symptoms and locking herald the separation of the foreign body from its bed and its emergence into the joint cavity. Colvin believes that unless pain and disability are severe, operation may be safely deferred until separation has occurred. The common location is on the mesial condyle in the immediate neighborhood of the posterior crucial ligament.

*Strains of Knee.*—Mauck,<sup>122</sup> in analyzing 159 cases of traumatic strain of the knee, finds that the most commonly injured structure is the internal lateral ligament, often in conjunction with the semilunar cartilage, and more rarely with the crucial ligaments. The histories show that, although the acute symptoms subside quickly, they are most prone to recur after very slight subsequent injuries unless they are rigidly immobilized for five to six weeks. After this the atrophied muscles must be redeveloped. Repairs of the internal lateral ligament by the use of the sartorius or semitendinosus tendons or by fascial transplants have been successful.

120. McClure and McCarty: Arch. Int. Med., Nov. 15, 1919.

121. Colvin: Minnesota Med., Feb., 1920.

122. Mauck: Virginia M. Month., April, 1920.

*Snapping Hip.*—In the *Journal of the American Medical Association*, and in articles by Mayer<sup>124</sup> and Manon,<sup>125</sup> attention has been called to the comparatively trivial but most annoying condition, described first by Perrin in 1859, and known as “snapping hip.” They all agree that it is commonly caused by an unusually thickened band of fascia or a thickened tendon of the gluteus maximus slipping over the trochanter. Division of this band relieves the subjective and the objective symptoms.

*Ankle Joint Infections.*—Chutro<sup>126</sup> has obtained joints that function very satisfactorily by performing an astragalectomy in the presence of infection. He uses an S-shaped incision, beginning above the external malleolus and descending along its anterior aspect to the line of the joint, then becoming almost horizontal as far as the tendon of the tibialis anticus, and thence descending vertically 2 or 3 cm. He lays special stress on displacing the foot well backward and holding it there by a bronze wire, which he removes in the fourth or fifth week. A figure-of-eight bandage from the metatarsal heads around the lower leg retains this position, and the patient is encouraged to walk before the wound is healed.

*Knee Joint Infections.*—Williams and Hetzel<sup>127</sup> compare sixteen cases of infected wounds of the knee joint in which no thorough voluntary mobilization (Willems’ treatment) was carried out, with eighteen similar cases of Willems’, in which there existed a purulent arthritis. In Williams and Hetzel’s series there was only one patient with 90 per cent. of motion as an end-result; in three patients there was no report as to motion; four died of subsequent infection; three underwent amputation; one resection, and four developed ankylosis. In Willems’ series, there were no deaths nor amputations; there was one resection, and there were only two resultant stiff joints.

Duval,<sup>128</sup> after a most extensive experience, becomes a strong advocate of Willems’ treatment, except in the hip joint, where in the presence of severe infection, he believes resection should be immediately performed. The two measures which he advocates are: (1) immediate arthrotomy, débridement, and complete suture up to thirty-six hours after injury; (2) immediate voluntary mobilization. The mortality from knee-joint wounds in 1915 was 27.5 per cent., and 30 per cent. of amputations. In 1916, 1917, 1918, there was a record of less

123. Snapping Hip, Current Comment, J. A. M. A. **74**:679 (March 6) 1920.

124. Mayer: Surg., Gynec. and Obst., Nov., 1919.

125. Manon: Presse méd., Oct. 29, 1919.

126. Chutro: J. Orthop. Surg., Sept., 1919.

127. Williams and Hetzel: Ann. Surg., Sept., 1919.

128. Duval: Surg., Gynec. and Obst., Sept., 1919.

than 1 per cent. of deaths, only 2.8 per cent. of amputations, and 86.5 per cent. of good results.

*Flail Joints.*—Jones<sup>129</sup> and Platt,<sup>130</sup> in two articles on the treatment of flail joints following gunshot injuries, agree that, in the elbow and knee, ankylosis gives the best functional result, but is hard to obtain in the elbow. In the shoulder they both urge careful and prolonged muscle training before any operation is attempted, the arm being maintained in abduction. Platt has been impressed with the improvement in function which he has obtained by lengthening the humerus by a mallet-shaped graft from the tibia inserted into the proximal end; but they both agree that a successful arthrodesis is preferable to a flail shoulder. Jones is convinced that by far the best method of obtaining ankylosis in flail hips is the lengthening of the femur by means of a sliding graft from its upper end and the fixation of it in apposition to a freshened acetabular surface.

*Arthroplasty.*—Schepelmann,<sup>131</sup> after experience with sixty cases, and Schmerz<sup>132</sup> believe that it is unnecessary, if not actually prejudicial, to insert any heteroplastic or autoplastic material between the ends of the bones in performing an arthroplastic operation. They maintain that the careful molding of the bones, by means of a file, to a semblance of the old articular contours is the most important measure. The lateral ligaments are carefully preserved. The bony ends are kept apart at first by traction, and motion is begun in a few days. They say that the bony ends become covered with a tissue which is an excellent substitute for cartilage, and resembles it.

[Ed. Note.—These reports are interesting, but at the present time not convincing. Far more detailed histories of cases must be given, with photographs and roentgenograms of end-results of more than a year, before we can safely abandon the previously accepted methods of performing arthroplasty. It is true that pseudarthroses occur when we do not wish them, but we believe that the interposition of tissue is their commonest cause, and operation often confirms this. Ely's findings (to be commented on later), after the experimental resection of dogs' knee joints, are interesting, however, in their possible bearing on this work of Schepelmann and Schmerz.]

#### FRACTURES

[Ed. Note.—In reviewing the mass of literature on fractures (almost 100 articles), we have been impressed with the general con-

129. Jones: British M. J., Feb. 7, 1920.

130. Platt: J. Orth. Surg., Nov., 1919.

131. Schepelmann: München. med. Wchnschr., 1917, No. 11.

132. Schmerz: Zentralbl. f. Chir., 1916, No. 47.

sensus of opinion as to the value of the Thomas splint in fractures of the lower limb, used either as an integral apparatus, or in combination with caliper, traction, suspension, etc.]

A valuable article among this series on the Thomas splint is by Billington,<sup>133</sup> who had wide war experience with this splint. He describes its limitations and its uses, the essentials of its exact pattern, and its application. He believes it should have a wide employment in civil practice.

Most of the articles review war services and report results which, by and large, are most encouraging. The limitations of the bone graft are also appearing, but the method seems to have been definitely accepted, and to have brought about results of most perfect character in shorter time than any other procedure. There seems to be a tendency to abandon the small or medium-sized graft, and to employ, on the one hand, with small bones like the radius and ulna, the thin osteoperiosteal grafts as advocated by Chutro and Delangeni re; or else to employ in bones like the femur, or in bridging gaps, a rather massive graft, accurately fixing the fragments and securing wide contact surfaces. If the graft be removed from the tibia, the precaution of removing it from the mesial surface, rather than from the crest, is advised, both because of the real danger of subsequent fracture of the tibia when it is taken from the crest, and also because of the more suitable structure of the bone for regeneration. It should comprise both periosteum, cancellous bone, and endosteum. The bone graft in bridging gaps grows chiefly from its two contact ends, and increases in thickness very slowly. It is prone to fracture at its central portion, but often reunites with the production of callus. We have selected for comment those articles which seem to us to teach useful lessons in the light of end-results, and to describe suggestive new methods of treatment.

*Pseudarthrosis.*—Dujarier<sup>134</sup> reports his results in thirty-five cases of pseudarthrosis of the humerus following war wounds. He has employed different methods. Metal plates were used in sixteen, with eight unions, five failures, and three not old enough to report. Silver wire was employed in nine, with seven successes. Osteoperiosteal grafts were inserted in ten, with eight successes. His operations were performed in the presence of sinuses and twenty followed a non-febrile course.

*Fracture of Lower End of Humerus.*—Vance<sup>135</sup> reviews the anatomy of the lower end of the humerus and its relations to the elbow

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133. Billington: J. Tennessee M. A. **12**:325 (Jan.) 1920.

134. Dujarier: Med. Rec., Aug. 23, 1919.

135. Vance: South. M. J., Jan., 1920.

joint. He believes the internal condylar fractures are more common than external, but that all should be treated by thorough anesthesia, careful reduction by manipulation, and the maintenance of this correction by the position of hyperflexion, usually secured by adhesive plaster and roller bandage. The dressing is always inspected the next day, and on the fourth is taken down and reapplied. After two weeks the hyperflexion is gradually lessened, at the end of four weeks the arm is in the sling position, and active (not passive) motion is stimulated by the fifth or sixth week. He reports successful results in twenty-four cases out of twenty-six, one of which was compound. In two it was impossible completely to reduce the displacement, but the patient obtained a useful arm.

*Fracture of Forearm.*—Lemon<sup>136</sup> recommends that all fractures of both bones of the forearm at the middle third be treated by fixation in full supination, at first in side splints extending to the elbow until the swelling subsides, and then in plaster of Paris extending well above the elbow and fixing it.

[Ed. Note.—We agree with Lemon as to his position, but believe that if the fracture be seen before swelling has occurred, it is not only safe, but desirable, to apply a carefully molded plaster in full supination, extending from the metacarpophalangeal joints to the upper third of the humerus, with the arm in almost full extension. If reduction is accurate, subsequent swelling rarely occurs, and under the close observation which these cases should always receive, pain and congestion of the fingers will suggest the necessity of splitting or bivalving the plaster.]

Troell's<sup>137</sup> article on fractures of the lower end of the radius is based on 200 personally observed cases and illustrated with over eighty excellent roentgenograms of the three main groups of fractures of the radius near the wrist. He emphasizes the differences between the types and the treatment of those fractures which occur while the ossification is still going on, and those in which the ossification is complete.

Cotton<sup>138</sup> calls attention to the dorsal rocking or rotation of the distal fragment in Colles' fracture, and maintains that the perfect reduction of this deformity is essential to perfect subsequent function. If this be left unreduced, it makes almost impossible the reduction of the ulnar luxation, which is perhaps the most important element in future disability. He maintains that after breaking up the impaction and reducing this dorsal displacement and rotation, the only position which successfully retains this reduction is one in which the hand is in

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136. Lemon: Wisconsin M. J., April, 1920.

137. Troell: Svenska Läk. Handl., Sept. 30, 1919.

138. Cotton: Boston M. & S. J., Dec. 4, 1919.

pronation and the wrist in flexion, i. e., the position exactly opposite to that in which the fracture was produced. He retains this position most perfectly by a plaster cast, for three weeks, leaving the fingers free. He emphasizes the great care necessary in application of this cast, because of the possible interference with circulation.

[Ed. Note.—We are in agreement with Cotton as to the advantage of this position in all difficult cases, and in old unreduced cases after operative reduction. We have found it usually safe to remove the plaster applied in extreme pronation and flexion in ten days or two weeks, and gradually to regain dorsal flexion of the wrist. We have appreciated the danger of long retention in this disabling position in elderly subjects, but with these precautions, unfortunate stiffness has been avoided, and it has been possible to maintain by this method reductions which have been difficult of retention by other methods.]

*Pelvic and Femoral Fractures.*—Peet<sup>139</sup> reviews the literature of 169 cases of fracture of the acetabulum with intrapelvic displacement of the femoral head. Not all these cases are clean cut, there being many complications, which were often serious. Falls on the trochanter were the common cause, and flattening of the hip, restriction of motion, and slight shortening, together with the indications of the roentgenograms, were the diagnostic signs. Open operation for reduction is rarely necessary, and in Vaughn's case pressure on the exposed femoral head from within the pelvis was unsuccessful. Reduction is by manipulation under full narcosis by downward and lateral pulls. Free motion should always be attained and retention in full abduction maintained for several weeks. No weight-bearing is allowed for three months.

Whitman<sup>140</sup> maintains that his position of full abduction is the ideal one for reducing and maintaining reduction of this fracture dislocation.

Davidson<sup>141</sup> has employed a portion of the whole fibula as a bone graft in fractures of the neck of the femur, and in one case substituted the head and a portion of the shaft of the fibula for the neck and head of the femur, with an excellent functional result.

Henderson<sup>142</sup> has also employed the whole thickness of the fibula as a graft in fractures of the neck of the femur, and believes it the best form of graft. He finds no disability of the lower leg from its removal. Of 120 cases of ununited fracture of the neck of the femur seen recently in the Mayo Clinic, only twenty-six were thought suitable for operation. There was no mortality. A U-shaped incision, detach-

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139. Peet: Ann. Surg., Sept., 1919.

140. Whitman: Ann. Surg., Jan., 1920.

141. Davidson: Surg., Gynec., and Obst., Aug., 1919.

142. Henderson: Surg. Gynec., and Obst., Feb., 1920.



ing the trochanter, was employed, and of the twenty-six cases, ten were successful, eight were unsuccessful, and seven results are unknown. The autogenous fibula graft gave the best results.

Campbell<sup>143</sup> analyzes his results in 116 cases of fracture of or about the neck of the femur. Of seventy new patients treated, mostly by Whitman's abduction method, five died, but almost all the others obtained union. Twenty-four of the twenty-nine intracapsular fractures gave excellent functional results, four were failures, and one patient died. Twenty-four of forty-four patients with old ununited fractures were operated on. Eleven of the fifteen operations in which the tibial graft was employed were successful. Of seven in which he employed a wire nail fixation only two were successful. He is enthusiastic over Whitman's abduction method in all fresh cases.

In a paper read before the American Surgical Association by Van de Velde,<sup>144</sup> an assistant to Depage, the following methods of treatment are recommended in gunshot fractures of the lower third of the femur: (1) in oblique or transverse fractures, wiring; (2) in fractures with slight comminution, direct skeletal traction by means of calipers or a Steinmann pin; (3) in all cases where the above methods are not applicable or where there is marked comminution, vertical suspension of the lower fragment by wire to an overhead frame attached to the splint, combined with longitudinal traction.

*Patella.*—Hewitt<sup>145</sup> is convinced that all fractures of the upper third of the patella demand operation to obtain union, while simple transverse fractures in the middle, with little injury to the fascial aponeurosis, may be treated conservatively. Refracture is common through the old callus, and is best treated by an inlay bone graft. The importance of maintaining the mobility of the patella while union is taking place is emphasized, since refracture from manipulation to repair knee motion is prone to occur. In connection with fractures of the patella, the olecranon and the os calcis, a retentive dressing, devised by Fisher of Budapest in 1910, but apparently not much known in America, is advocated by Foldes.<sup>146</sup> Two pieces of adhesive plaster are cut into fan-shaped strips, 3 or more inches long. At the apex of the fan, the plaster is folded on itself to form a strong fan handle. The two fans are applied to the skin above and below the fracture, the fan handles meeting over the fracture. One fan handle is perforated for the other handle to glide through it, in order to approximate the frag-

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143. Campbell: *Ann. of Surg.*, Nov., 1919.

144. Van de Velde: *Ann. of Surg.*, Oct., 1919.

145. Hewitt: *J. Missouri M. A.*, March, 1920.

146. Foldes: *Surg., Gynec., and Obst.*, May, 1920

ments. The pull is now exerted on the ends of the handles, in Fisher's apparatus, by fastening them to the ends of a small adjustable leaf spring. In Foldes' modification, the pull is maintained by leading cords attached to the fan handle ends over pulleys on the ends of a small curved wood bar, maintaining their traction by means of turn buckles, and a central spring resting on top of the curved wooden bar. Thus, as much traction as the skin will stand can be maintained, pulling together the tissues above and below the fracture.

Campbell,<sup>147</sup> on the basis of three cases, recommends early transference of the denuded head of the fibula into the upper portion of the tibia in cases of large defects. After this he inserts an inlay graft, the transplanted fibula offering increased blood supply, better splinting, and stability. It has been possible by this method to lengthen the leg  $1\frac{1}{4}$  inches.

Delbet, Girode, and Congremoulin,<sup>148</sup> after experimenting with rubber implants in bone and finding them well tolerated, report the details of two successful clinical cases of defects in the radius. The stumps of the bone were fitted with covers, and a reinforced rubber shaft was fitted into these receiving covers. They say the results after seventy and eighty-eight days are perfect from an orthopedic and functional point of view.

#### AMPUTATIONS

Most of the recent discussion concerning methods of amputation has centered around motor plastic operations or cinematization. The Italian surgeons are most enthusiastic over the possibilities, as is evidenced by the articles of Arana,<sup>149</sup> Pellegrini,<sup>150</sup> and Scalone.<sup>151</sup> Moreover, enthusiasm as to actual results and future development is not confined to the followers of Vanghetti and Putti. Tuffier,<sup>152</sup> after a trip to Italy, is convinced that the principle is sound and many of the results remarkable. He believes that actual wage earning force can be provided as soon as more mechanically perfect prostheses can be devised. The clinics of Putti at Bologna and Galeazzi at Milan demonstrated cases of upper limb amputation which had been greatly benefited. He urges surgeons to save as much skin and muscle as possible, sacrificing the cosmetic appearance of the stump end to the possible future and greater success of cinematization.

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147. Campbell: *J. Orthop. Surg.* Oct., 1919.

148. Delbet, Girode and Congremoulin: *Bull. de l'Acad. de méd. de Paris*, June 29, 1919.

149. Arana: *Semana méd.*, Aug. 21, 1919.

150. Pellegrini: *Riforma med.*, Dec. 20, 1919.

151. Scalone: *Chir. d. org. di movimento*, Feb., 1920.

152. Tuffier: *Bull. de l'Acad. de méd. de Paris*, Jan. 13, 1919.

Gunn and Gallie,<sup>153</sup> after a visit to Putti's military clinic at Bologna, recommend a complete reconsideration of the question of treatment of men with amputations of the arm. They believe that a great many could be immediately benefited by the cinematic amputations as practiced by Putti.

In a discussion of cineplastic amputations before the British Orthopedic Association, the president, Mr. E. Muirhead Little,<sup>154</sup> enumerates the essentials as (1) sufficient motor power; (2) well nourished and innervated skin covering; (3) ample range of motion; (4) sufficient length and thickness; (5) and appropriate surface for counter pressure, covered with well nourished and resistant skin. The upper limb offers more possibilities than the lower, the motors being limited to flexors and extensors. "Club" motors seem to be more practical than the skin-lined tunnels.

Putti,<sup>155</sup> in certain amputations in the forearm, has slit the stump for about 10 cm., separating the bones and suturing the skin about them, making two sausage-shaped prongs, between which objects can be held.

*Lengthening Stumps.*—Gallie,<sup>156</sup> in the light of one case, believes that in certain cases of thigh amputation in which the fragment of the femur is too short (less than 3 inches below the lesser trochanter) for the useful application of an artificial limb, it is possible to increase the length of the shaft more than 2 inches by an inlay or medullary graft, or by slitting the stump of the femur and sliding one half downward, fixing it with beef-bone screws. This latter is the method he successfully used, but there was a good deal of bleeding from the femoral shaft and a certain osteoporosis about the beef-bone screws.

*Amputation Through the Foot.*—Corlette<sup>157</sup> has devised three new amputations of the foot, each conserving the calcaneal tread. The article is a long one, with a careful review of the regional anatomy, and is worthy of perusal.

There is general agreement that the Chopart and Pirogoff amputations should be abandoned. Orr<sup>158</sup> thinks that a properly performed Lisfranc is serviceable, and not too difficult to fit. Irwin,<sup>159</sup> and, it may be said, many other surgeons, believe that unless a good plantar flap can be saved, an amputation through the ankle, after the method

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153. Gunn and Gallie: *Canad. M. A. J.*, Aug., 1919.

154. Little: *J. Orthop. Surg.*, April, 1920.

155. Putti: *Chir. d. org. di movimento*, Feb., 1920.

156. Gallie: *Lancet*, Aug. 16, 1919.

157. Corlette: *Med. J. Australia*, June 14, 21, 28, July 5, 1919.

158. Orr: *J. Kansas M. Soc.*, Dec., 1919.

159. Irwin: *British J. Surg.*, Jan., 1920.

of James Syme, is the method to be strongly advised. It is essential for a good result from a Symes to have a clean field, and to perform a most carefully planned plastic operation.

#### RESEARCH

*Phagocytic Action of Osteoclasts.*—Shipley and Macklin<sup>160</sup> question, as a result of their study of phagocytic cells throughout the body by certain special dyes, the phagocytic action of the osteoclast. They prefer, like Metchnikoff, the name macrophage to phagocyte, and believe that these cells are derived principally from the lymphocytelike cell of the blood stream, but locally may have their origin from large mononuclear cells which show phagocytic potentialities.

*Periosteum.*—Gallie and Robertson,<sup>161</sup> after thoroughly reviewing the literature and conducting many animal experiments, conclude that the periosteum has no osteogenetic power, and must not be relied on to produce new bone. They even consider that its presence or absence is of no moment in autogenous grafts. Its importance lies in the fact that in living bone it controls the circulation, and any extensive stripping is liable to lead to necrosis and, if sepsis is present, to sequestration. Therefore, there should be the least possible disturbance of circulation in all bone operations.

*Bone Transplantation.*—Brooks<sup>162</sup> begins by pointing out the value of being able to accurately observe the site and amount of bone regeneration that occurs in bone transplantation experiments through the intravital staining reaction confirmed by the use of a dye, lazarin red. This dye is injected extraperitoneally at stated intervals during the fixation of the graft. It has the property of staining all growing bone to a bright red color. A series of bone transplantation experiments was carried out in dogs, which seems to establish the fact that in the absence of periosteum and endosteum, regeneration and growth of bone does not occur. A second important item is that the osteogenetic power of the bed of the bone into which the graft is fixed varies directly with the age of the animal. Thus, in many of the older animals, where the conditions of operation otherwise seemed all in favor of bone junction of the graft, unfavorable results were of frequent occurrence, apparently from the absence of bony spaces in the graft adequate to acquire proper nutrition for the transplanted bone. As a practical issue, therefore, it apparently is important to consider the general osteogenetic power of the individual as a whole before advising a bone-grafting

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160. Shipley and Macklin: Some Factors in Bone Repair, Editorial, J. A. M. A. **74**:604 (Feb. 28) 1920.

161. Gallie and Robertson: British M. J., Oct., 1919.

162. Brooks: Southwest J. M. & S., March, 1920.

operation. A second principle that seems to be established by these experiments is that local traumatism of the site from which the graft is taken may stimulate a process of bone growth in the graft before its removal, as a two-stage operation.

*Persistence of Free Bone in Tissues.*—Ely,<sup>163</sup> while conducting a series of experiments on resection of joints, buried portions of the removed bone in the anterior thigh muscles. In five of his experiments the bone buried was first boiled, and in seven it was transplanted raw. None of the boiled bone could be recovered after 150 days, while the raw bone remained longer, and in one case persisted for 1,103 days. He concludes that raw bone resists absorption better than boiled bone, but that it is also slowly absorbed.

*Experimental Resection of Joints.*—Ely's<sup>164</sup> research in relation to the resection of the knee joints of dogs is very suggestive, especially in the light of the work on arthroplasty of Schepelmann and Schmerz previously alluded to. Ely found that after a section of both joint surfaces, unless absolute apposition and immobility were provided, the whole tendency was toward a separation of the bone ends by fibrous tissue and fibrocartilage and the formation of a new joint. He points out that in an ordinary fracture of a shaft, Nature provides this apposition and immobility by callus formation, but that if this callus does not for some reason form, a false joint may be expected to result, unless the bone ends are held in closest contact. Callus does not form after joint resection; hence, unless the mechanical requirements of complete rest can be satisfied, resection of joints is not followed by bony ankylosis.

*Pseudarthrosis.*—Albee,<sup>165</sup> after experiments at U. S. Army General Hospital No. 3, at Colonia, concludes that in rabbits pseudarthroses cannot be produced by removal of pieces of bone, imperfect immobilization, or massive doses of roentgen rays. As a result of his observation of a large number of patients, he concludes that the roentgen rays in no way inhibit union in fractures in human beings. Union was shown where bony fragments between bone ends had been removed.

Albee<sup>166</sup> also experimented on dogs, and found that if one fourth of an inch of a dog's radius was removed on both sides and on one side a 5 per cent. solution of triple calcium phosphate was injected, union on the control side occurred on an average in forty-two days, while on the side of the injection the average time was thirty-one days.

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163. Ely: Ann. Surg., Dec., 1919.

164. Ely: Ann. Surg., Nov., 1919.

165. Albee, G. H.: Restoration of Loss of Bone, J. A. M. A. **74**:589 (Feb. 28) 1920.

166. Albee: Ann. of Surg., Jan., 1920.

*Nutrition of Articular Cartilage.*—Strangeways<sup>167</sup> states that it has been the general opinion that the nutrition of cartilage cells is from the arterioles in the neighboring tissues, but microscopic examination does not make this clear. He examined histologically four loose bodies (free joint mice), taken from different knee joints. In all of these, active proliferative changes could be demonstrated, and presumably nutrition was well carried on after separation. One may suppose that this nutrition might come from the death of some cells, but this was disproved, as the fragments increased in size. He argues that the nutrition must have come from the synovial fluid. Conversely, he believes that the degeneration of the cartilage seen in certain types of arthritis may be explained in this way. It is possible that these changes in the nutritive value of the synovial fluid may be due to changes in the vessels of the capsule, e. g., arteriosclerosis.

#### CEREBROSPINAL FLUID AS AN INDEX OF COMPRESSION OF THE CORD

Ayer,<sup>168</sup> after experiments on cats and from an analysis of personally observed cases, believes that Froin's syndrome, i. e., a yellow, rapidly clotting spinal fluid, containing an excess of protein, is almost pathognomonic of spinal cord compression, usually rapidly progressive. He also believes that Nonne's syndrome, i. e., a moderate or considerable increase in protein content, without increase of cells, yellow color, or quick clotting, is a very delicate and trustworthy test for lesser degrees of pressure. In his experiments on cats, in which compression was caused by injection of paraffin, these findings were constant below the lesions, while the fluid above, withdrawn from the cisterna magna, was normal.

[Ed. Note.—We believe this experimental work and these findings of Ayer are of great value. It is often important, and difficult, to determine complete or partial compression of the spinal cord in the paralyses and paraplegias of cervical caries. In fractures and dislocations of the spine, and in neoplasms with cistern puncture above the lesion and lumbar puncture below, we may expect to obtain in doubtful cases valuable information as to the spinal cord pressure.]

#### APPARATUS

*Mechanical Laboratory.*—Thomson<sup>169</sup> points out that one great difficulty which the surgeon whose work includes the treatment of lesions of the extremities and spinal column meets is the quick obtain-

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167. Strangeways: British M. J., May 15, 1920.

168. Ayer: Arch. Neurol. & Psychiat., Aug., 1919.

169. Thomson: J. Orthop. Surg., April, 1920.

ing of apparatus. This apparatus, while often very simple, must also be often of a special character. While in large centers properly equipped brace shops are usually available, it is a great convenience and saves much time to have one's own mechanical laboratory. In more remote communities it is almost a necessity. Thomson describes a simple workshop equipment, costing \$300. He suggests simple standard appliances.

*Direct Bone Traction.*—Cannady<sup>170</sup> has devised an excellent caliper for direct bone traction. The points are made with a guard ring, and there is a locking device to prevent loosening. The calipers are so made that they can be used in a vertical position, thus permitting full extension of the knee.

*Special Splints.*—Cleary<sup>171</sup> has devised, as a result of long army service, several new, ingenious, and extremely useful splints, especially one for comfortable, light and efficient abduction of the shoulder. He also describes original elbow splints for regaining flexion and extension, and for supination and pronation of the forearm.

Conn,<sup>172</sup> from a U. S. Army and an industrial point of view, has written a useful article reviewing the different types of braces for the lower extremity, and illustrating their application.

LeMesurier<sup>173</sup> contributes a similarly descriptive paper on apparatus for nerve injuries, for disabled joints, and feet, and for amputations, which have been found useful in Canadian experience.

Cunningham,<sup>174</sup> under the title of a "New Adhesive Material for Traction," advocates a 5 to 10 per cent. solution of celluloid in acetone. Its advantages are that its rapidly volatilizing quality makes immediate traction possible, and that it is waterproof and therefore not affected by perspiration or climate.

[Ed. Note.—We have tried this adhesive material in several cases and find that the advantages which Cunningham claims for it exist, but unfortunately we have found also in the solutions which we employed, prepared after his directions, a great tendency to marked skin irritation and blistering. In fact, the reaction of the skin has been so marked in our cases that we have felt obliged to abandon the method.]

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170. Cannady, J. E.: Caliper Extension in the Treatment of Fractures of the Femur, J. A. M. A. **73**:1281 (Oct. 25) 1919.

171. Cleary, E. W.: Special Splint for Certain Injuries and Disabilities of the Extremities, J. A. M. A. **73**:1495 (Nov. 15) 1919.

172. Conn: Surg., Gynec., and Obst., Dec., 1919.

173. Le Mesurier: Med. Quart., July, 1919.

174. Cunningham, W. F.: A New Adhesive Material for Traction, J. A. M. A. **73**:973 (Sept. 27) 1919.

## MISCELLANEOUS AND BOOK REVIEWS

*Habitual Dislocation of the Shoulder.*—Ollerenshaw,<sup>175</sup> after an operative experience with three cases in which he employed the deltoid flap method as described by Clairmont in 1909, believes that this method offers the best means of overcoming the tendency to recurrent dislocation of the shoulder. It provides a good sling for bracing up the head and neck of the humerus, which sling contracts when the rest of the deltoid is in action, as it is in abduction, when dislocation is most prone to occur. The operation is performed by making an anterior and a posterior incision. The anterior exposes the deltoid in front and splits it. The posterior runs parallel to the posterior edge of the deltoid, and  $1\frac{1}{2}$  inches laterally to the line. A flap is taken from the posterior deltoid and passed from behind forward, to be sewed into the split in the deltoid in front.

*Differential Diagnosis of Hip Disease.*—Legg<sup>176</sup> has taken 1,000 consecutive cases of hip disease, and from the study of these has made a classification of symptoms by which the various lesions may be differentiated. Besides the conditions naturally related to this joint, he considers Pott's disease of the lumbar portion of the spine, appendicitis, retroperitoneal glands, bursae, infantile paralysis, and other conditions that may be confusing to the diagnostician.

*Thrombo-Angiitis Obliterans.*—Meyer<sup>177</sup> believes that in patients, especially those of the Jewish race who have an inherited weak sympathetic nervous system and, as a corollary, subnormally functioning eliminating glands, the constant flooding of the body tissues with tobacco smoke poisons is likely finally to lead to thrombo-angiitis obliterans and intermittent claudication, perhaps ending in gangrene. His conclusion is that people constituted as these Jews are should not smoke.

Cornet<sup>178</sup> greatly relieved a patient suffering from intermittent claudication by applying a Bier's passive hyperemia band about the thigh for two hours daily for a few days. There was a retrogression of the entire syndrome, edema, hypo-esthesia, hypothermia, and purpuric patches, as well as the pain.

*Bone Deformities of Renal Dwarfism.*—Barber<sup>179</sup> found bony changes in five out of eight cases of interstitial nephritis appearing at the age of puberty. These changes consisted of knock knees, and broadening of the epiphyseal lines, similar to rickets and dwarfism.

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175. Ollerenshaw: J. Orthop. Surg., May, 1920.

176. Legg: Boston M. & S. J., June 10, 1920.

177. Meyer: Med. Rec., March 13, 1920.

178. Cornet: J. de méd. de Bordeaux, Oct. 25, 1919.

179. Barber: Lancet, Jan. 3, 1920.



The paper is suggestive in relation to the still obscure etiology of the so-called adolescent rickets.

*Résumé of Extremity Surgery of the War.*—Danforth<sup>180</sup> has written two useful articles reviewing the advances and the final consensus of opinion in the surgery of the extremities, and in the diagnosis and preoperative treatment of peripheral nerve injuries. In nerve lesions absence of improvement for two months is held to be an indication for exploratory operation, if motor loss, cutaneous sensibility loss, trophic disturbance, or pain constitutes a disability.

Sir Robert Jones<sup>181</sup> important résumé of joint, nerve, and other injuries in war surgery, represents the judicial conclusions of a virile, observant surgeon, whose experience with the end-results of almost every method of treatment has been the widest of which we have knowledge.

*The Problem of the Cripple.*—The very exhaustive survey of cripples which has been made in the city of Cleveland is reviewed by McMurtrie.<sup>182</sup> The definition of a cripple which was accepted was "a person whose (muscular) movements are so far restricted by accident or disease as to affect his capacity for support." In Cleveland there were found to be 4,186 cripples or six in every 1,000 inhabitants. Sixty-three per cent. were males; in 43 per cent. the condition was due to accident. In children, 41 per cent. of the cases were due to poliomyelitis, in adults 13 per cent.

Jones and Girdlestone<sup>183</sup> have estimated that in Great Britain 45 per cent. of the crippling conditions of childhood are due to paralytic or congenital deformities, and 40 per cent. to tuberculosis or rickets. They believe the care and cure of these ought to be a government responsibility, and suggest a districting of the country, with an open-air orthopedic hospital and associated clinics in each district. This need is by no means confined to Great Britain, and there are signs that the need is being recognized.

*Reconstruction.*—Goldthwait<sup>184</sup> has been impressed with two great needs of physical reconstruction in the army: (1) the careful functional reeducation following the first surgical treatment of the casualties, and (2) the postural and physical training of the very large numbers of accepted recruits who soon broke down from weak feet, weak backs, and generally poor bodily mechanics almost as soon as they entered the army. Four or five weeks of this postural training was often

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180. Danforth: Rhode Island M. J., Jan., 1920; J. Orthop. Surg., Oct., 1919.

181. Jones: Surg., Gynec. and Obst., Jan., 1920.

182. McMurtrie: Med. Rec., Aug. 23, 1919.

183. Jones and Girdlestone: British M. J., Oct. 11, 1919.

184. Goldthwait: New York M. J., Sept., 1919.

enough to salvage these men, enabling them to stand up to the severe physical exertion which service in the ranks entailed.

Johnson,<sup>185</sup> writing on the time element in reconstructive surgery, draws very sane conclusions: (1) Time is necessary for conservation and reconstruction. (2) Time is valuable to the patient in many ways, and to the state or the employer as a financial consideration; therefore it cannot be invested without adequate return improvement. (3) Time spent in prolonged treatment is dangerous to the patient. (4) Therefore improvement must be greater, the greater the time involved. (5) The dangers of time must be minimized by (a) reduction to a minimum of confinement to bed; (b) keeping the patient in touch with the world of his normal life even though he is in bed, through personal interest and appropriate occupation, lectures, etc.; maintenance of mental tone throughout confinement in the hospital; (c) adequate employment in workshops for all ambulatory cases; (d) reeducation and vocational training in certain cases.

#### BOOKS

ORTHOPEDIC AND RECONSTRUCTION SURGERY, INDUSTRIAL AND CIVILIAN. By F. H. Albee, M.D., F.A.C.S., etc. Philadelphia, W. B. Saunders Co., 1919.

In a large volume of over a thousand pages the author has well covered the field of orthopedic surgery, making this an excellent book for the advanced student. With its bibliography, its systematic arrangement and profusion of illustrations, it offers a good book of reference for the surgeon. It is hardly a textbook of orthopedics, because it has almost nothing to say on statics and posture, or on the mechanical or physiotherapeutic treatment of deformities. The author may well be excused for his devotion to the bone graft, which leads him to devote many pages to the different uses to which it may be put. This subject and the mechanical instruments of bone surgery are newly developed, and such explicit directions are needed to spread this knowledge.

MENDERS OF THE MAIMED. The Anatomical and Physiological Principles Underlying the Treatment of Injuries to Muscles, Nerves, Bones, and Joints. By Arthur Keith, Conservator of the Museum and Hunterian Professor, Royal College of Surgeons, England. London, Oxford University Press, 1919.

To understand a great nation, one must read its history and learn to know the great characters who have made it. To understand the principles of orthopedic surgery, one should read the rich chapters of this book and learn to appreciate how Hunter, Hilton, Thomas, and the

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185. Johnson: J. Orthop. Surg., Jan., 1920.

American School have inculcated these principles. The book is delightful reading, because the human element is brought into such close relation to the subject matter that one seems to be actually sitting at lectures under these great masters.

INDUSTRIAL MEDICINE AND SURGERY. By Harry E. Mock, M.D., F.R.C.S. Philadelphia, W. B. Saunders Co.

Industrial surgery is a new subject and it should receive a great impetus from such a comprehensive book as this. In its 800 pages, there are only 100 pages devoted to true surgery, injuries, fractures and amputations. There is much new study on industrial health service and prevention. Compensation and medicolegal phases are discussed and there are excellent chapters on Americanization, human conservation and reclamation of the disabled. To the industrial surgeon, the book offers much on medical treatment of employees, medical examination of applicants, and avoidance of accidents and disease.

A MANUAL ON FOOT CARE AND SHOE FITTING FOR OFFICERS OF THE U. S. NAVY AND U. S. MARINE CORPS. By W. L. Mann and S. A. Folsom. Philadelphia, P. Blakiston's Son and Co.

It will be unfortunate if such clear concise little manuals as these brought out by the war are not to find a more general reception. In this small pocket volume there is much that applies to the civilian in industry.

PHYSICAL RECONSTRUCTION AND ORTHOPEDICS. By Henry Eaton Stewart. New York, Paul Hoeber, 1920.

Published as a royal octavo with large print, this book is pleasing to the eye, and the illustrations are interesting. It deals a little with massage, a little with electricity, hydrotherapy and vocational therapy. The chapter on infantile paralysis and scoliosis is perhaps somewhat superficial. In treating the former he recognizes no separate muscles nor groups of muscles, giving exercises for the arm or leg as a whole. The subject of fractures is given fifty pages, in which most of the varieties are mentioned, but the treatment is not carefully outlined.

## Editorial Review

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### CONGENITAL CLEFT OF THE LIP AND PALATE

In this special field of surgery the number of cases is surprisingly large. The subject is most interesting and presents many problems. The operative measures reach the highest plane of reconstructive surgery.

Sentiment often leads to ill advised effort; but in these cases the appeal for help is strong and the satisfaction of success immeasurable. The results as regards looks and function are vital to the patient. It is imperative that the profession pay more attention to those so afflicted and that those most interested agree or approximately agree on several debated questions.

#### EMBRYOLOGY

The embryology of the deformity is well established and is reviewed in various books and articles notably by Berry and Legg<sup>1</sup> and by Brophy.<sup>2</sup> Karl Grünberg<sup>3</sup> presents a very complete study of the embryology of man and of other animals. Fraeser<sup>4</sup> reviews the subject and explains many anatomic facts, at the same time emphasizing points that may be interpreted as having a bearing on the surgical repair. Appended to his paper are twenty-seven references.

The study of the embryology is essential for any one undertaking this type of work for several important facts are disclosed which bear directly on our concept of the general considerations of the subject as well as on the surgical measures to be employed.

The various defects and the many combinations of them are explained by this study, which shows that the developing structures find origin in three separate processes or centers: two lateral and one anterior. The lateral processes give rise to the superior maxillae, the anterior to an overhanging, entering wedge, the premaxilla. Fraeser says: "The clefts of the palate and face form a complete series in which all degrees of separation are present in lines of fissure normally present at one period." The dimension of length enters into the union. This complicated process may result in failure at any point, at several points or at every point along the line.

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1. Berry and Legg: London, J. and A. Churchill.

2. Brophy, T. W.: Oral Surgery, Philadelphia, P. Blakiston's Son & Co., 1915.

3. Grünberg, Karl: Monograph, Jena, Gustav Fischer, 1913.

4. Fraeser, J. E.: Practitioner **99**:401 (Nov.) 1917.

If the above rough sketch of this intensely interesting feature of the subject is accepted, it will substantiate the statement that the so-called harelip and cleft palate and their many combinations are the result of failure in the same embryologic process of union. This may be taken as the first proposition which embryology suggests, as bearing on the general consideration of the subject.

Brophy italicizes the statement that the clefts are not the result of loss of tissue. All the tissue that the baby is entitled to is there but in improper position and out of contact. There is every evidence that this is true and it is important when some of the surgical measures for the closure of these defects are considered.

It is a clinical observation that Nature makes an attempt to unite the bony structures by bony union and not by mere contact.

Berry gives a series of tables giving the age of the embryo, at which the several tissues unite. These indicate that the sequence is from before backward. In examining a number of pig embryos at the University of Minnesota, Scammon has shown that the hard palate not infrequently unites in the middle before it does anteriorly or posteriorly, but that the sequence of closure of the lip and alveolar process is constant. This observation may or may not be important but the sequence in which normally these tissues are closed may suggest to us the surgical procedures to be used.

From the study of the embryology four statements can be made which are of interest to us from the surgical standpoint:

1. The lip and palate defect are not two separate entities but a failure in the same embryologic process of union.
2. All tissues are present but out of contact.
3. The clefts once normally present normally close from before backward.
4. The palate bones normally unite by bony union.

#### ANATOMY

This review may be made from many sources. Eastman,<sup>5</sup> in a paper everywhere easily obtained, has presented the anatomy of the palate in a most complete and delightful way. The article is well illustrated and readily understandable.

One must be familiar with the disposition of the artery of the hard palate, the function of the muscles of the soft palate, the artery of the frenum, the circular artery of the lip, the obicularis muscle, the depressor alae nasi, all of which structures enter into the technic of

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5. Eastman, J. R.: The Surgical Anatomy of Cleft Palate, J. A. M. A. 65:915 (Sept. 11) 1915.

the operation. The anatomic terms should also be familiar. These are definite except the terms alveolar arch and alveolar process which are used synonymously although the use of the word arch has little foundation while the term process is correct.

#### GENERAL CONSIDERATIONS OF THE SUBJECT

The greatest opportunity for advance is in a revision of the descriptive terms and the acceptance of some common classification on which to exchange opinions on the time honored problems of the age at which the operation should be performed, the sequence of operations and the technical details. There are several reasons why this would be of great advantage.

The descriptive terms are all anatomic and not surgical. Those in use are simple, single, double, complete, partial incomplete, complicated, first degree, second degree, third degree, unilateral, bilateral, tripartite, bipartite, cleft of the uvula, cleft of the hard palate, cleft of the soft palate, etc. Many of these indicate surgery only by implication. The choice of them singly or in combination varies with the individual surgeon, and there is no law or order governing their use. This looseness of terminology permits one to describe the same surgical problem in several ways and likewise to describe different problems by the use of the same terms.

This statement can be proved by comparison of several articles in books and magazines. Discussions and exhaustive papers are not always clear in the terminology employed.

Harelip is a fanciful term without embryologic, anatomic or surgical foundation, and is only used as a simile; and incorrectly, for the hare has a median cleft while in man, except in the most unusual cases the cleft is lateral. Embryology indicates that harelip is a cleft lip and that it differs nowise from cleft palate except that the cleft involves separate structures. The two terms harelip and cleft palate, together with the anatomic terms tend to create the impression that each defect is a separate surgical problem, a detached condition with but little relation to the whole subject. So frequently are they associated and their surgical treatment so interlocked that they should not be divorced. It would, therefore, be of great advantage to dispense with the term harelip. We are not discussing harelip and cleft palate but congenital cleft of the lip and palate. This is the first requirement for those interested in the discussion of this subject.

The second requirement is the establishment of some classification of the extraordinary varieties and many combinations of the defect. This classification should be founded on the surgical procedures used in repair rather than upon the anatomic conditions, such as is now the case.

Anatomically there are fifteen forms of cleft palate (Brophy). There are several forms of cleft lip, which in combination with clefts of the palate, present an array of anatomic conditions which are most confusing unless grouped or classified from a surgical standpoint.

The student is usually at sea when this subject is mentioned. Graduates from different medical schools have diametrically opposed ideas of treatment and no common ground for information. This has led to confusion not only among the profession generally but among surgeons of wide experience, eminently qualified to deal with any surgical problem but who make no attempt in this field or retire after a failure. There are, however, those with an aggressive temperament who attempt this work after insufficient preparation and with little or no information. Not infrequently results are detrimental to the patient.

I<sup>6</sup> recently suggested that the critical situation in every case of congenital cleft of the lip and palate affecting the surgical repair is the condition of the alveolar process. If the baby is born with the process normally closed, no matter what the extent of the defect anteriorly or posteriorly, the principles of the operation are pretty well established and the technical measures comparatively simple. If the baby is born with the process open, unilaterally or bilaterally then the problems are greatly increased and the series of surgical steps becomes involved. I suggested four groups, defined as follows:

Group 1. All forms of cleft lip in which the process is normally closed.

Group 2. All forms of cleft palate in which the process is normally closed.

Group 3. All cases of unilateral cleft of the process.

Group 4. All cases of bilateral cleft of the process.

This plan gives the opportunity to speak of a Group 1 case and Group 3 case as defining a group based not upon anatomic location of the cleft but upon the surgical requirements for repair. A Group 1 lip and a Group 3 lip may be operated on in the same way but if in a Group 1 lip the operation is successful it indicates that it was a completed case while in a Group 3 lip it shows that the operation was only a part of a series of operations necessary in the reconstruction of the case.

Sherman<sup>7</sup> objects to this grouping as awkward and unintelligible. He accepts the proposition that the condition of the alveolar process forms the foundation for a surgical grouping and suggests that the

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6. Ritchie, H. P.: *Minnesota Med.* 4:15 (Jan.) 1921.

7. Sherman, H. T.: Personal communication.

condition of the process be indicated in every case as follows: (1) pre-alveolar cleft; (2) postalveolar cleft; (3) unilateral alveolar cleft, and (4) bilateral alveolar cleft.

This grouping is made for these reasons:

1. The groups correlate all combinations with the embryologic facts.
2. They separate the combinations according to their special surgical requirements.
3. They indicate directly the paramount surgical condition, the condition of the alveolar process.

It is a question whether the conclusions and plan can be considered logical and be accepted. It is nevertheless true that some revision is necessary in order that we may arrive at conclusions with regard to many debated problems, for ourselves, for the profession at large and for the patient.

#### SURGICAL CONSIDERATIONS OF THE SUBJECT

Our elaborate differential diagnostic methods essential to other surgical conditions are unnecessary when dealing with this defect. The deformity is evident and can only be repaired by operative measures. That many patients are neglected and seek aid at late periods in life should only stimulate the profession to keener interest because it is no uncommon report from the patient that he was advised by a physician that the operation might very well be postponed. This situation is often interpreted to mean an extended time which the patient, with a natural fear of surgery, puts off to remote periods. This is particularly true in the postalveolar clefts when the deformity is not evident and the patient voluntarily comes during school life when he finds he is different from his fellows or comes in early manhood, or womanhood, when he desires to marry.

Therefore, the question of the age at which the operation should be performed and our advice to the patient are vitally important. Upon this there is a great difference of opinion. It is quite difficult to quote opinions in regard to age without considering that most debated question of all, the sequence of operations. This discussion is limited mostly to one group of cases, the unilateral alveolar cleft. It extends, of course, to the bilateral alveolar group. These cases are not so evident in the literature, probably because they are not so frequent by half and also because there are special steps which require attention in the fourth group not present elsewhere. There are occasional cases of pre-alveolar and postalveolar clefts in the same individual, but the problems of the third group are not applicable in this condition.



The question of sequence of operations is an important one as it is this question which has cast a haze of uncertainty over the profession as to the proper procedure in any case. Any one doing this work is perfectly familiar with the expression, "Are you a cleft palate man or do you do the lip first?" Articles entitled "Harelip and Cleft Palate" and "Cleft Palate and Harelip" have been published. It is impossible to review the literature upon these two questions of age and sequence of operation. Only a few excerpts from the American literature will be given. Every writer makes the important qualification that any statement depends upon the condition of the child.

Brophy<sup>2</sup> operates as early as possible; the first day and always before three months using his well known procedure upon the palate. Lane is quoted by Davis<sup>8</sup> as favoring the first day, using the flap eversion method advocated by him.

Roberts<sup>9</sup> says, "First operation during first month upon alveolar process in front of hard palate, then a little later upon the lip and still later upon the palate." He places wires through the cheeks and fixes them over a cork. The process is closed by wire suture. Horsley<sup>10</sup> operates on the lip when the child is 2 weeks old and closes the alveolar process with a single wire suture at the same time. The palate is closed at 6 months. Sherman<sup>11</sup> operates when the child is 3 or 4 months old, but really begins when the child is "15 pounds old." He advocates the use of adhesive plaster for the lip while waiting to perform the palate operation. He says, "The anterior parts are definitely narrowed by this means. As soon as the broken ends of the alveolar arch overlap, the child is ready for operation on the palate." He operates on the soft palate first by splitting the uvula after a manner attributed to Ferguson. Later, he repairs the anterior part of hard palate.

Brown<sup>12</sup> says, "There are many reasons why good results may be obtained by closing the lip first and the palate afterward that cannot be obtained by reversing the order of procedure." The lip should be operated on at the earliest possible time. Good results can be obtained at any time in the first two or three months. He closes the lip first, and as soon as this is healed closes the anterior part of palate, usually from 4 to 6 months of age, then the soft palate one year later.

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8. Davis, J. S.: *Plastic Surgery*, Philadelphia, P. Blakiston's Son & Co., 1919.

9. Roberts, J. B.: *Osteoplastic Operations for Complicated Cleft Palate*, Internat. Clinics **4**:220, 1918.

10. Horsley, J. S.: *Virginia M. Monthly* **47**:97 (June) 1920.

11. Sherman, H. M.: *The Repair of Cleft Palate*, J. A. M. A. **69**:1966 (Dec. 8) 1917.

12. Brown, G. V. I., in Ochsner, E. H.: *Surgery*, Philadelphia, Lea and Febiger **1**:577, 1920.

Blair<sup>13</sup> closes the lip during the first 6 months, the palate within the first 2 years. Within the first twenty-four hours is an ideal time. Up to the first three months he believes the Brophy operation practicable but "after 3 months it is best not to attempt forcibly to close an open alveolar cleft either by fracture or sudden bending. The repair of the lip across the cleft will cause the latter to close gradually and will usually bring the bony parts in good relative position."

Berry is the champion on all occasions of operating on the lip first at an early date and the palate later, up to a period of 2 years, advocating the Langenbeck operation.

These quotations are most inadequate; but they seem sufficient to show the trend of opinion. They reveal a great difference of opinion among men of wide experience and keen observation not only as to time of operation but also as to the methods.

In pre-alveolar and postalveolar defects a reasonable conclusion can be drawn. In the former the effort is purely cosmetic; little interference with function is present. As a technical problem it is a superficial operation; a simple procedure depending upon good hemostasis and therefore can be performed at any time in the judgment of the operator. Delayed operation does not interfere with the success which can be obtained with equal facility the first day or in later life. Associated with a minimum of shock and danger the operation should be done as early as possible provided the condition of the child permits.

In postalveolar cleft, the operation is more severe with greater danger of loss of blood. It is often longer, sometimes quite difficult and there is more chance of postoperative complications. The baby must be more carefully considered. The tissues are quite delicate and will stand but little traumatism. Regurgitation of food occurs and may be of serious consequence to the nourishment of the child; but ordinarily spoon feeding maintains health. As regards speech function there is no reason for performing the operation until the end of the first year. It is also frequently noted that what appears as a very wide cleft at birth becomes appreciably narrower as the child grows. The aspirator does away with the necessity of frequent sponging and consequently one source of difficulty is removed. These should be done before the first year at a time which the surgeon considers most favorable. In this condition, Sherman's expression of "15 pounds old" is applicable.

In cases of unilateral cleft of the alveolar process, the problem is the hiatus in the process. In the review of the contentions of the exponents of mechanical pressure, lip pressure and adhesive strap pressure, one underlying fact is appreciated by all. This is the clinical

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13. Blair, V. P.: *Internat. Clinics* 4:211, 1916.

observation that the bones of the face and palate are pliable and do not become fixed and rigid under an arbitrary period of 3 months. This movability not infrequently extends over a longer period, and closures are effected at a later time by both the compression methods and lip closure. But it is necessary to agree upon some definite time as a dividing line between certain and uncertain results of the several methods of treatment. Most writers mention 3 months as an average time. Therefore treatment must begin before this time since afterward the bones may become set and closure may become more difficult. From all angles, then, there is every reason definitely to agree that any treatment must be started at the earliest possible moment and not later than 3 months.

In this group the alveolar cleft must be closed. The exponents of forcible compression, as employed in the Brophy operation, the use of single wires, etc., argue that the situation is comparable to a fracture. In discussing Sherman's paper, Brophy says, "Complete cleft palate is not unlike a fracture of bone, separated sutures or ununited fracture." Clinical evidence shows that when the palatal processes approximate normally, they unite by bony union; but it surely is a debatable question as to whether they ever do so as a result of surgical efforts. Some one has compared this condition to a compound fracture; the closing of the lip being compared to the closing of the skin wound, without applying splints to the fracture. If this comparison is correct, then a great percentage, if not all, result in ununited fractures. Dental roentgenograms fail to show bony union in any case that I have seen.

This is a very important question to settle as it deals with the fundamental reasons for our efforts, as to whether success in looks and function depends on bony union or merely the closure of soft parts.

Successful cases are observed in which no bony union takes place, and the question arises as whether the effort to obtain bony union is necessary. If the forcible compression methods are promulgated as comparable to fractures then they result in nonunion and therefore are presented on a wrong premise. If, however, we accept them as preliminary steps, required in order to facilitate the closure of the soft parts, they have a reasonable foundation and are placed equally on a plane with lip and adhesive strap compression.

We have evidence that closure occurs in all these methods. Brophy is positive in his statements. Berry and New<sup>14</sup> are correct in saying that equally good results may be obtained by first closing the lip.

There can be no debate as to the efficiency of the forcible compressions. They cause approximation as is claimed for them. This

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14. New, G. B.: *Minnesota Med.* 1:8 (Jan.) 1918.

approximation is confined to the alveolar process only. The cleft palate is narrowed, but as regards closure further steps are necessary. The operation has been misconstrued as an operation on the palate, whereas the result is closure of the process only. These methods then must be considered as accessory measures rather than primary steps. As a routine procedure they are surely not necessary. It is easy to demonstrate that the alveolar hiatus is frequently closed within ten days after the lip operation. On the other hand cases can be shown in which the lip was first approximated and an incomplete closure of the process occurred. This happens only occasionally and can often be explained because the result on the lip, which remains deformed, was unsatisfactory.

The balance of evidence and opinion is in favor of the lip palate sequence in the unilateral alveolar cleft operation series. To discard entirely the methods of forcible compression would not be wise as they are most efficient; but their acceptance as a method for every case in this group is not substantiated.

Their position in the surgical treatment of this defect will be that of special selection in the patient with a wide cleft or in the delayed case in which, in the judgment of the surgeon, active pressure is needed to render easier the following closure of the soft parts.

The same conclusions in the treatment of the bilateral alveolar cleft may be drawn. The double cleft adds another step, as does the projection in varying degrees of the premaxilla. A more extensive repair is required and more difficulty not only in constructing the lip but in applying plates and wire is encountered. It is true that the results are usually as satisfactory if not more so than in any combination of the defect. This may be explained by the fact that the deformity is so grotesque that the parents will not allow delay and the patients are seen and subjected to treatment at the earliest possible moment.

The removal of the premaxilla is universally deprecated as unnecessary. If it is removed the resulting deformity is but a little improvement over the original condition. It is still being removed by the uninformed and every one doing this work has such cases brought to him. Lorenz<sup>15</sup> has written the only paper advocating its removal as a routine method, and he suggests what appears to be a complicated plan for the reconstruction of the lip. This method has been followed in this country and those using it are positive in their statements as to its efficacy. The illustrations which Lorenz shows support his assertions.

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15. Lorenz, H.: *Deutsch. Ztschr. f. Chir.* **87**:410-424, 1917.

It would seem too dangerous because good results are obtained by first operating on the lip. Brown has aptly said that our purpose is the replacement of tissues normally and not the disarrangement of them. This is a proposition applicable to other technical suggestions, and particularly is it applicable when actual removal of tissue is advocated.

The vomer is usually cut. Some illustrations are given in which the incision is so long that any such replacement would result in a situation comparable to removal. Very often the cleft is not wide and cups are present on the maxilla, ready to receive the rounded surface of the premaxilla. In this group the preliminary adhesive strap pressure yields its most satisfactory result. In narrow clefts the lip operation will force the bone into position without any of the accessory steps. In most cases, it is wise to cut a small V for the vomer before operating on the lip.

The evidence in regard to age in the sequence of operations is: (1) in pre-alveolar cleft the earliest possible time compatible with the condition of the child; (2) in postalveolar cleft, before speech function is developed, but whenever technically possible to be done at "15 pounds old"; (3) in unilateral alveolar cleft, first step to be used before the child is 3 months old and much earlier when indicated. The lip to be constructed first and the palate when the child is approximately 1 year old. Mechanical compression to be undertaken first in the selected case and not as a routine procedure. (4) In bilateral alveolar cleft, same recommendations as in Group 3 except that the vomer should be carefully incised as a preliminary step.

#### ASPECTS OF THE OPERATION AND TECHNICAL DETAILS

There are five different methods of dealing with the palate; the Langenbach-Warren, Lane, Brophy, Brown and Sherman. In the older literature, the lip operations were more discussed. My chief, the late J. E. Moore, and his associate, J. Clark Stewart, while doing this work, collected about nine different operations upon the lip: Nelaton, Malgainge, Dizy, Smith, Rose and several others.

Through the years many suggestions upon incisions, angles of incisions, suture material and methods of insertion, instruments and position have accumulated.

What can be the solution of a problem when such a multiplicity of methods and details are promulgated, which have evidently been used over a period of years, manifestly yielding satisfactory results and yet in many instances directly opposed in surgical principle?

The only answer is that there must be some underlying principles that will permit of all this discussion and debate.

Those incisions of the lip which require diagrams are complicated and few of us have surgical acumen sufficient to select the proper angles for the individual case. These plans do not take into consideration the extraordinary movability of the face tissues. Any one who has reconstructed a lower lip excised for epithelioma, performed plastic operations upon the neck or on the face, appreciates the remarkable distance these structures may be mobilized, their extraordinary vitality, healing so frequently under marked tension. The case is not different in the upper lip. Straight line incisions give greater assurance of proper healing than angles. The movability of the lip and this principle directly indicate straight line incisions and lateral approximation.

In bilateral pre-alveolar clefts and bilateral alveolar clefts, Brown has appreciated this principle and closes each cleft separately. The difficulty arises in properly approximating the vermilion border. Usually this operation is performed by two lines, two thirds of which are attached to the prolabium on either side and the lower one third of the lateral sides approximated below forming a Y closure. The angle on the prolabium may be contrary, but the results are much better than when the prolabium is pared squarely, as is frequently illustrated in operative procedures, as there is too much chance of a very evident deformity. The Y closure permits of building the lip high up on the premaxilla and any excessive lip below is sure to result in the "monkey face." The situation lends itself to the use of a "crucial" stitch such as was used in the earlier perineorrhaphies.

Another general surgical principle of great importance is the knowledge that we are dealing with three layers of tissue, the skin, muscles and subcutaneous tissue and the mucous membrane. A transfixation stitch will contract any denuded surface and since broad surfaces enhance healing it is indicated that we employ tissue to tissue approximation. It appears unnecessary to be careful to close all layers separately. In the lower lip, we close the mucous membranes in one layer and the skin and muscle by our tension and skin sutures in another. For cosmetic reasons it is suggested that we include the mucous membrane and muscles in one line of suture and the skin, to be nicely apposed, in a separate line. Two series of suture lines are therefore indicated.

The greatest difficulty in the lip repair of any of the three surgical groups is the reposition of the alae.

Wires placed through the nose and anchored on lead plates are suggested. Overcorrection is advocated. Both accomplish the purpose. The important point is the appreciation that the nostril has a definite floor, varying in length but always present. It does not seem reasonable to expect one stitch to make a wide approximation. Two stitches

are indicated. It is to be observed that the nostril floor is at right angles to the lip, therefore the stitches should be properly placed.

The approximation of the vermilion border may or may not be easy. In pre-aveolar clefts, the margins are not infrequently symmetrical and lend themselves most readily to the Rose operation. In unilateral alveolar clefts, one margin is often shorter than the other and when incised along straight lines the short side tends to roll in, producing a corkscrew effect. If the incision in the mucous membrane is made longer than in the skin the defect is usually overcome.

The requirements in the lip repair are (1) reposition of the alae; (2) approximation of the vermilion border; (3) a long lip, and (4) a thick lip. To accomplish these, the principles involved are: (1) straight line incisions; (2) wide denudation of the mucous membrane; (3) two point suspension of the alae; (4) two series of sutures, and (5) a clean wound.

If these are met the selection of suture materials and method of application are entirely within the judgment of the operator. Until one is *sure of his technic removable sutures should be used.*

The palate has received the greater attention during the last twenty years and rightfully so, as a successful result at the first sitting from any procedure is not always assured. So many uncontrollable circumstances are encountered that are not met with in the repair of the lip. The suture line is influenced by the tongue on one side and nasal discharge on the other, the tissues are but slightly movable and have no vitality or resistance comparable to those of the face.

Because of the undeveloped sense of the new-born and the greater ease of control, Brophy and Lane<sup>16</sup> are exponents of the operation upon the palate at the earliest date, during the first week or more correctly speaking during early infancy. Lane closes the lip at the same time saying, "If harelip exists, the cleft or clefts in it are closed at the same time as the cleft palate." He gives three reasons, the third of which is quite significant. "The third reason is that the sooner the pressure of the complete lip is brought to bear upon the segments of the upper jaw as well as the displaced maxilla, should it exist, the more rapid is the approximation of the bones forming the front of the cleft."

Berry<sup>17</sup> says, "The operation by median suture, a modification of Langenbeck's, is the only one which restores the palate to its natural condition. If the median operation were attempted at this early period it would usually fail unless preceded by the wiring operation of Brophy, which I believe it is dangerous to employ. The reason for postpon-

16. Lane, W. A.: *Lancet* 1:6-11, 1908.

17. Berry, James: *Surg. Gynec. & Obst.* 20:85, 1915.

ing the palate operation for a year or two is that after suture of the lip the cleft in the palate undergoes rapid narrowing and the development of the arch higher."

Eastman<sup>18</sup> believes that in the Langenbeck or similar flap operations there is less chance of failure in the union of the median line suture if it is supported by a continuous relaxation suture in the anterior palatal arch. Brown<sup>19</sup> elaborates principles governing the choice of operation on the palate. These are in effect not destruction or misplacement of tissue but natural replacement, and "not to exceed reparation possibilities of tissue in flap formation by endeavoring to close completely at one operation the palatal fissures of cases in which this is inadvisable." As before stated, he closes the lip first and in this quotation justifies his anterior partial closure of the palate.

Sherman closes the soft palate first and therefore obtains lateral pressure fore and aft upon the anterior hard palate.

Brophy's contentions are so well known that it seems unnecessary to repeat them. It may be observed that Lane stands alone in advocating rearrangement of tissue in closing the fissures. In his article flaps are shown which are turned to meet requirements in the postalveolar cleft, and these are different in the unilateral alveolar cleft and likewise different in the bilateral alveolar cleft. This suggests the complicated operations upon the lip and requires keen judgment in selection of the lines of incision. The method cannot therefore become of common practice and universal use. The proof of the vitality of the flaps and the success possible even when extensive give us a valuable step in reconstructing palates as a secondary procedure. There are also a small number of flat roofs usually in neglected cases which can be repaired in no other way. The procedure must therefore assume an accessory rôle; a valuable, though occasional one.

The evident and direct method of closing the cleft, accepted now quite commonly, is the separation of the mucoperiosteal flaps, and the freeing of the soft parts from the palate bone. The Gothic and Norman arch comparison is correct. The trap door simile is proper. This is the Langenbeck-Warren operation.

Two surgical principles are involved: relaxation and approximation of broadly denuded surfaces. Unless the arch is high, the flaps may not be apposed without tension and the lateral incisions are suggested. High arch and lateral incisions are the only possible means for securing approximation. Lane's flaps require no such consideration. The lateral incisions are seldom required provided early lip repair has taken

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18. Eastman, J. R.: *Surg. Gynec. & Obst.* **20**:91, 1915.

19. Brown, G. V. I.: *Surg. Gynec. & Obst.* **20**:87, 1915.



place. The advocates of mechanical measures assure us that they are never required. One thing is certain, they are never necessary in such length and position as often illustrated. They should receive the last consideration; but when in the opinion of the operator it is considered that they would be of advantage, there is absolutely no reason why they should not be used. The use of plates on the palate, of tapes through the relaxation incisions, in fact, any procedure which adds foreign material other than the median suture line, should be entirely discarded.

Approximation of wide surfaces is essential. Mere contact invites defeat. There is only one way to procure this in the hard palate and that is by the use of the mattress suture.

There is some question as to whether the cleft margin should be pared. It is of great advantage to save this mucous membrane, although it is very thin and has little vitality, as it protects the real structure of the hard palate below. The mattress suture builds a raised seam on the mouth side and this thin edge with a few single stitches gives an added assurance of success. In the treatment of soft palate defects several suggestions may be made. The mattress stitch is not necessary. Single sutures on the mouth side and extending around the uvula and up the nasal side give the best results. Figure of eight sutures, one or two, such as are used for tension and the skin suture in the breast flaps and abdominal wounds may be used.

The operation on the soft palate seldom fails, as great relaxation may be obtained by under cutting even through the posterior palatal arch. This is a very questionable procedure and one not to be advised, as muscle function must be intact in order to preserve future speech. But the first thing is to get union, and if this section is necessary the incision must be made in one line only for muscle cut in one plane often heals to function properly. The most uncertain cases of soft palate union are in the postalveolar clefts which have been neglected. After years, the structures are small and undeveloped and there is but little tissue to work with. Berry shows many cases in which speech function is well nigh perfect even when the palate was not closed at 3 years of age and we may be over anxious when this operation is attempted at 1 year or earlier.

Two improvements in my operating room equipment have greatly facilitated this work. They have removed many of the dangers of the operation. One is the bellows, long distance anesthesia, and the other is the aspiration outfit: one shortens the time of operation, the other helps respiration and minimizes postoperative pneumonia.

## CONCLUSIONS

Meticulous care is required in all steps of the operation. Details of the preliminary treatment and after-treatment are peculiarly exacting. The opportunity to secure a large number of cases depends upon a wide territory, large population, institutional work, or the evident results of personal effort to obtain a sufficient series to have dealt with the condition in all of its aspects.

The nature of the work tends to individualism in technical details, which one must select and develop; but this fact does not detract from the statement that details must be founded upon the principles of plastic surgery.

The greatest need is for the revision of the classification of cases and the grouping of descriptive terms, and the acceptance of a definition of the subject founded on fact.

Sherman's definitions of the surgical groups based upon the anatomic situation of the alveolar process is a reasonable plan of nomenclature.

The effort of surgical repair should be directed toward the replacement of tissue out of contact with as little disarrangement as possible.

All except the exponents of early mechanical measures admit the mechanical effect of the early lip repair, and eminent authority substantiates the statement that the effect of the two procedures is equal.

This statement does not detract from the efficacy of the former but gravely questions their necessity. They are surely not to be used as routine measures.

The evident course is given in the normal embryologic processes, undertaken at the earliest possible moment, following Nature's path and upbuilding her form.

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# ARCHIVES OF SURGERY

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## PERFORATING HEMORRHAGIC (CHOCOLATE) CYSTS OF THE OVARY

THEIR IMPORTANCE AND ESPECIALLY THEIR RELATION TO PELVIC  
ADENOMAS OF ENDOMETRIAL TYPE ("ADENOMYOMA" OF THE  
UTERUS, RECTOVAGINAL SEPTUM, SIGMOID, ETC.)\*

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The serious, though unusual, hemorrhage of ovarian origin into the peritoneal cavity simulating ruptured tubal pregnancy is well known to every abdominal surgeon, even though he may have encountered but few such instances in his own practice. The literature on this subject has been recently reviewed by Novak<sup>1</sup> and by Smith.<sup>2</sup> The larger ovarian cysts, also with hemorrhagic contents due to twisting of the pedicle of the cyst or from other conditions, are so obvious as to make it impossible to overlook them. Ovarian hematomas due to various causes have been reported by Savage,<sup>3</sup> Wolf,<sup>4</sup> Hedley,<sup>5</sup> Novak<sup>6</sup> and others.

There is, however, one type of hemorrhagic ovarian cyst or ovarian hematoma which should receive more careful attention; not only on account of its frequency but because of the nature of the adhesions resulting from the escape of its contents into the peritoneal cavity. These cysts are often bilateral and are usually small, from 2 to 4 cm. in diameter, though they are occasionally smaller than 2 cm.

\*Read in part before the American Gynecological Society, June 3, 1921.

\*From the gynecological and pathological departments of the Albany Hospital and the Albany Medical College.

1. Novak, Emil: Abdominal Hemorrhage of Ovarian Origin, *J. A. M. A.* **68**:1160-1162 (April 21) 1917.

2. Smith, R. R.: Hemorrhages into the Pelvic Cavity Other than Those of Ectopic Pregnancy, *Am. J. Obst. & Gynec.* **1**:240-247 (Dec.) 1920.

3. Savage, S.: Hematoma of the Ovary and Its Pathological Connection with the Ripening and Retrogression of the Graafian Follicle, *Brit. Gynaec. J.* **21**:285-305, 1906.

4. Wolf, E. H.: Ueber Haematoma Ovarii, *Arch. f. Gynäk.* **84**:211-243, 1908.

5. Hedley, J. P.: Hematoma of the Ovary with Report of Eighteen Cases, *J. Obst. & Gynec. Brit. Emp.* **18**:293-311, 1910.

6. Novak, Emil: Hematomata of the Ovary Including Corpus Luteum Cysts, *Bull. Johns Hopkins Hospital* **28**:349-354 (Nov.) 1917.

and larger than 4 cm. They apparently develop in women during their menstrual life, especially from 30 years of age to the menopause. I believe that many of the cases described by Savage,<sup>3</sup> Wolf<sup>4</sup> and Hedley<sup>5</sup> belong to this group. A very good example of this type of cyst is described by Smith,<sup>2</sup> under the title of hematoma ovarii.

At operation the ovary containing such a cyst is found to be adherent because of a previous perforation and is ruptured in freeing it. The perforation had been sealed by whatever structure the cyst, at that site, had become adherent to, such as the posterior wall of the uterus, posterior layer of the broad ligament or peritoneum of the side of the pelvis.

During some period in the life of these cysts (or possibly many, times), material escaped from them into the peritoneal cavity which was very "irritating" and gave rise to adhesions. These adhesions occur most often in the dependent part of the pelvis, namely the culdesac.

The contents which escape, in freeing the cyst at operation, look like chocolate syrup. The amount varies with the size of the cyst, the size of the opening and the consistency of the contents. Adhesions are encountered which vary in extent, density and location in different cases. They may be slight, as those resulting from a mild pelvic peritonitis of tubal origin, or extensive and dense causing the parts involved to become fused with one another and thus making their separation extremely difficult. The most extensive and densest adhesions are usually found in the culdesac uniting the supravaginal portion of the cervix and lower portion of the posterior wall of the uterus to the bottom of the culdesac and the anterior rectal wall. These adhesions vary in extent and degree in this situation and are sometimes so dense as to simulate malignancy. The operator deals with the individual case according to his best judgment at the time and usually considers the adhesions due to some previous pelvic inflammatory disease. For many years, this was my attitude toward this condition, and judging by the gynecologic textbooks which I have consulted (fifteen in number) all but two of the writers were either unaware of the adhesions resulting from the rupture of ovarian hematomas or did not consider them of sufficient importance to mention them. The two authors who do mention them refer briefly to adhesions resulting from the rupture of an ovarian hematoma or hemorrhagic cyst.

I believe that the whole subject is of great importance from an economic, clinical, pathologic and even physiologic point of view. These cysts are of frequent occurrence. I have had fourteen cases during the year, May 1, 1920, to May 1, 1921, in 178 abdominal operations for pelvic conditions in women between 30 and 50 years of age.

They affect women in a most valuable period of their lives, usually from 30 years of age to the menopause. The variation in size of the cysts, with the varying extent and denseness of the adhesions, leads to mistakes in diagnosis both before and during the operation. The smaller cysts with slight or moderate adhesions may be mistaken for pelvic inflammatory disease of tubal origin; the larger cysts with dense adhesions for malignant ovarian cysts and the dense adhesions in the culdesac for the implantation of cancer, or, when the rectal wall is extensively involved, for rectal cancer. Many kinds of operations have been performed to relieve the condition resulting from these cysts:

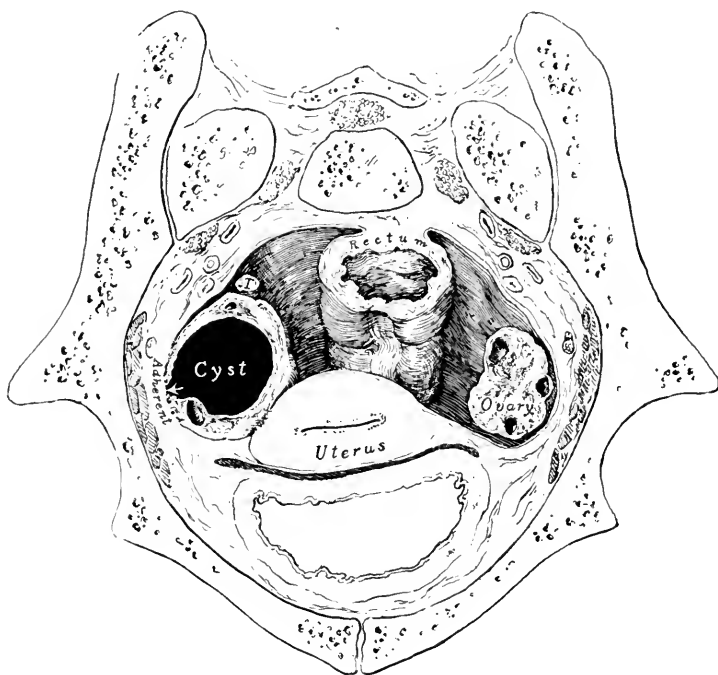


Fig. 1 (Case 11).—Cross section of the pelvis showing the condition found at operation;  $\times \frac{1}{2}$ . The ovarian cyst had ruptured and the perforation was sealed by the peritoneum of the side of the pelvis to which the ovary had become adherent. On freeing the ovary, its "chocolate" contents escaped. The histology of the ovary is shown in Figures 2, 3 and 4. Tissue was not removed from the side of the pelvis adherent to the ovary to determine whether or not adenoma of endometrial type was present.

conservative operations in which the adhesions have been severed, a portion of an ovary excised or one tube and ovary removed; radical operations, with the removal of the uterus, tubes and ovaries, and still more extensive operations in which a portion of the large intestine has been excised, with or without the removal of the uterus, tubes and ovaries.

Of histologic and pathologic interest is the finding in these ovaries of tissue of endometrial type lining the wall of the hematoma and also

often in pockets in the ovary especially about the site of perforation. This tissue may also often be found in the structures which are involved in the adhesions, as the organ or tissue to which the ovary or cyst is adherent at the site of perforation and in the folds formed by the tube and ovarian ligament, the tube and the round ligament, the vesico-uterine fold of peritoneum, about the uterosacral ligament, and bottom of the culdesac, namely, in places in which the hemorrhagic contents escaping from the rupture of the ovarian hematoma would be likely to settle. The most extensive development of this adenoma of endometrial type is usually found in the culdesac, sometimes as a localized thickening; other times as a diffuse growth involving the posterior surface of the supravaginal portion of the cervix, the posterior uterine wall, the bottom of the culdesac and the anterior wall of the rectum, all of which may be adherent to one another. The process

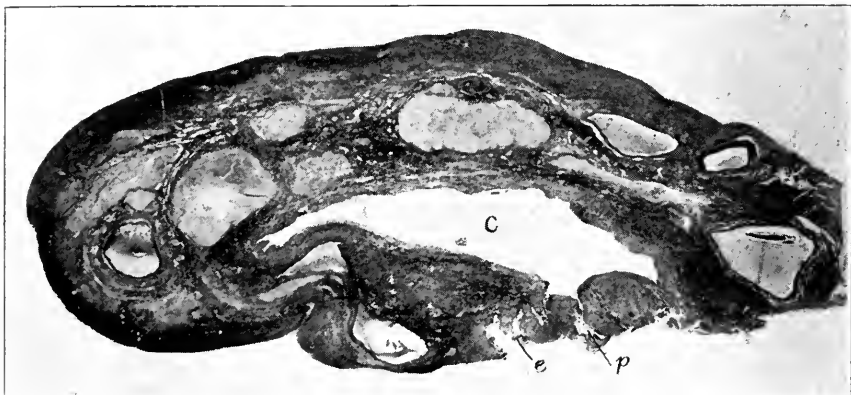


Fig. 2 (Case 11).—Enlargement ( $\times 4$ ) of a stained cross section of the ovary, cyst collapsed and empty. The cyst *c* is for the most part lined by low epithelium which lies directly on the ovarian tissue with ut any intervening stroma (Fig. 3). There are in the ovarian tissue about the perforation *p* depressions or small clefts *e* lined by columnar epithelium with gland formation and a stroma which is vascular and in places hemorrhagic. These areas strongly suggest misplaced uterine mucosa (Fig. 4). From a histologic study of this cyst one would hesitate to say that it is a hematoma of endometrial type. Nevertheless, hematomas may be found in "adenomyoma" of the uterus with a similar lining. The latter should be our standard of comparison in studying ovarian hematomas rather than the normal uterine mucosa (Fig. 6).

may even extend out between the layers of the broad ligament or between the rectum and vagina, the latter giving rise to "adenomyoma of the rectovaginal septum."

Of physiologic interest, it is to be noted that the adenoma of endometrial type developing in the ovary and arising in the portion of the pelvis as the result of the escape of the hemorrhagic contents of the ovary may be the seat of periodic hemorrhages, i. e., they may be "menstruating organs." Such hemorrhage or menstruation from the ovary would escape into the cavity of the cyst or into the peritoneal

cavity to be absorbed or to give rise to secondary foci of adenoma of endometrial type in various portions of the pelvic cavity. The secondary pelvic foci usually remain quiescent except for slight hemorrhages into the lumen of the glandlike spaces forming small "hematomas" (hemorrhagic cysts). Sometimes they are invasive, and when so are apt to invade the uterus, forming an "adenomyoma" or they may grow down between the rectum and the vagina, forming an "adenomyoma of the rectovaginal septum" and may penetrate the vagina and appear in the posterior vaginal vault. In other cases, they may extend through the wall of the rectum or sigmoid. The "menstrual" blood may escape into the vagina or the large intestine depending on which structure is penetrated by the growth.

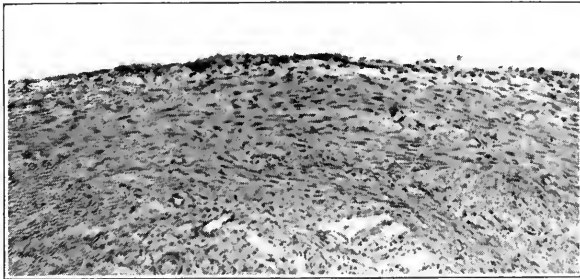


Fig. 3 (Case 11).—Photomicrograph of the wall of the cyst shown in Figure 2. The cyst is in places lined by a single layer of low to cuboidal epithelium resting directly on the ovarian tissue without any intervening vascular stroma. The condition is similar to that shown in Figure 6, a section of the wall of a hemorrhagic cyst due to the retention of "menstrual" blood in an "adenomyoma" of the uterus.

#### THE INCIDENCE OF PERFORATING HEMORRHAGIC CYSTS OF THE OVARY

My attention was first directed to the dense peritoneal adhesions which may result from the escape of the contents of these cysts, in the year 1910 (Case 1). At the operation, March 8, of that year, a myomatous uterus with bilateral adherent, medium-sized ovarian cysts was found. When these cysts were freed, "chocolate" colored fluid escaped. The lower portion of the posterior uterine wall was firmly adherent to the rectum, and these structures were separated with great difficulty. The supravaginal portion of the cervix was so adherent to the rectum that a supravaginal hysterectomy was performed and the pelvis drained through the dilated cervical canal. The anterior rectal wall felt so indurated after the removal of the uterus that I thought the patient might have a malignant growth of the rectum. I made a digital rectal examination before the patient left the operating room.

While the induration in the anterior rectal wall could be distinctly detected, the rectal mucosa over it felt normal. The patient developed a postoperative ileus which was relieved by an enterostomy. She eventually recovered and has never had any trouble from the rectal condition. At the time I thought that the condition might be syphilitic and advised her family physician accordingly. In view of my present knowledge of these conditions, I believe that the adhesions probably arose from the cyst contents and that there was present an "adenomyoma of the rectovaginal septum." It was only after I had removed other similar cysts that I began to recognize that the adhesions accompanying these cysts arose from the escape of their hemorrhagic contents into the peritoneal cavity. I have since been impressed with the fact that the diagnosis of such a definite clinical and pathologic entity should be made before the operation.

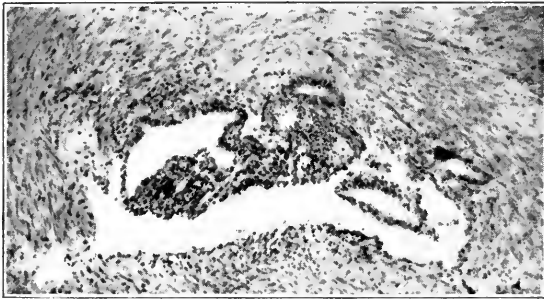


Fig. 4 (Case 11).—Photomicrograph of a small pocket (*c*) in the periphery of the ovary near the perforation of the cyst shown in Figure 2. Histologically, it closely resembles endometrial tissue, the epithelium, stroma and gland formation are the same. This tissue did not resemble the depressions lined by the typical surface epithelium of the ovary which were present in the same section.

The association between these cysts and "adenomyomas" of the posterior uterine wall with adhesions between it and the rectum was first observed by me, in 1912. March 27 of that year, I removed an "adenomyomatous" uterus in which the "adenomyoma" had apparently extended through the posterior uterine wall and had invaded the anterior wall of the rectum (Fig. 64, Case 2). On section, the "adenomyoma" was apparently not connected with the uterine mucosa. Bilateral perforating hemorrhagic cysts of the ovary were present. Just a month later I encountered a similar condition which would have been overlooked had it not been for the first, as the "adenomyoma" was much less extensive (Case 3 and Fig. 63). I did not observe another similar condition until June 13, 1918 (Case 6), but I undoubtedly had overlooked many. During the years 1918 and 1919, I observed



these cysts many times and studied them more from the standpoint of gross pathology, basing the microscopic studies solely on the routine examination of the material in the pathologic laboratory. I found that this was inadequate, and, therefore, I am reporting only a few of the cases observed by me during that period. Until a year ago, I believed that the adhesions arose solely because the contents were exceedingly irritating; that they contained a digestive ferment (menstrual) or were infected by some bacteria. Cultures were made and proved sterile, and some experimental work on animals was done which will be considered later.

It was only this last year that I fully realized the true relation between these cysts and pelvic adenoma of the endometrial type and

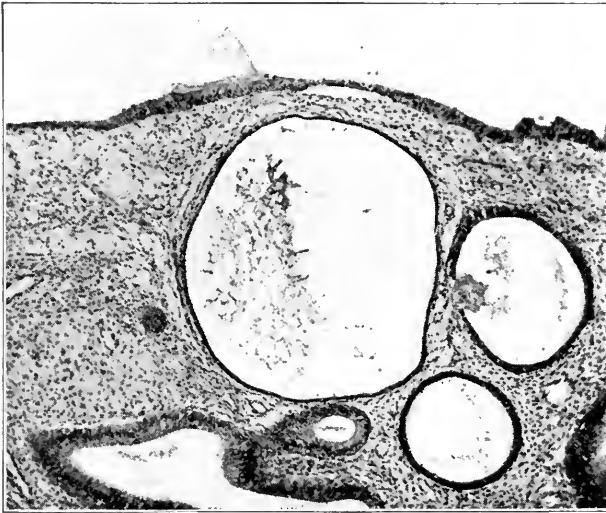


Fig. 5.—Photomicrograph of a portion of uterine mucosa showing glandular dilatation. The epithelium lining these glands is columnar, cuboidal or low varying with the dilatation of the glands. The greater the dilatation (distention), the lower is the epithelium lining the gland. The same holds true for hematomas of endometrial type whether of the ovary or the uterus. (Compare with Figure 3 and also Figure 6.)

that the pelvic adhesions were often associated with or were in large part due to this adenomatous growth.

From May 1, 1920, until May 1, 1921, I have operated on fourteen patients with these cysts, and in ten, an adenoma of the endometrial type was found in the organs or tissues which were adherent. In the four in which it was not found, the adhesions were slight, conservative surgery was performed and tissue was not removed from the adherent structures for microscopic examination.

#### PATHOLOGIC ANATOMY

*A. Pathologic Changes in the Ovary.*—As previously stated, these hemorrhagic cysts are found at operation to be adherent, and in freeing

them, the cyst is ruptured and some, or all, of its contents escapes. This rupture arises from reopening a previous perforation which has been sealed by the organ or structure to which the cyst has become adherent at the site of the perforation, or the cyst is torn in freeing it. Adhesions are also found in other portions of the pelvis and especially in the culdesac, and these adhesions are apparently the result of the escape of the contents of the cyst. The cyst with the evidence of a previous perforation is often the only apparent cause for the adhesions which occur in situations where fluid or contents from a ruptured cyst would tend to fall or accumulate. I have found at operation, in four instances, evidence of recent "hemorrhage" into the pelvis from this source. The situation and extent of these adhesions vary greatly in different cases. The pathologic conditions found at operation also vary and depend on many factors, such as the size of the cyst, its situation in the pelvis, whether unilateral or bilateral, the situation and extent of the adhesions

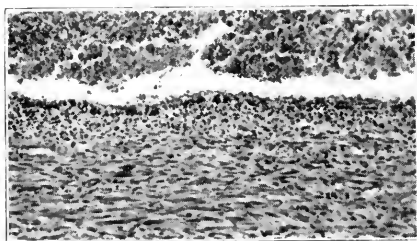


Fig. 6.—Photomicrograph of the wall of a hemorrhagic cyst (hematoma) present in an "adenomyoma" of the uterus. This hemorrhagic cyst is due to the retention of "menstrual" blood. It is lined by a single layer of epithelium, cuboidal on the left and low on the right. The epithelium rests on the uterine tissue with little or no evidence of an intervening "endometrial" stroma. The hemorrhagic contents of the cyst are shown retracted above the epithelial lining. Histologically, the lining of this hematoma (uterine) and the one shown in Figure 3 (ovarian) are similar.

and secondary changes associated with, or arising from, these, and finally other pathologic conditions in the pelvis which may occur in women of the same age incidence.

The size of the cysts has already been discussed. It is usually between 2 and 4 cm., occasionally larger; the largest one in this series was approximately 9 cm. in diameter. They are often bilateral, eight out of the twenty-three cases in this series; when unilateral, the right ovary was involved in nine, and the left, in six instances.

The structure or organ to which the cyst is adherent at the site of perforation varies. In this series of cases the posterior surface of the uterus was most frequently involved (Fig. 38); then the posterior surface of the broad ligament (Fig. 27); the peritoneum lining the side of the pelvis (Fig. 1), and in one instance the anterior surface of the broad ligament and the round ligament (Fig. 47), that is, any

organ or structure which may be in contact with the ovary or cyst at the site of perforation. There are two rather characteristic features about the gross appearance of these cysts after their removal. One is the perforation with a raw area of ovarian tissue about it, where it was adherent (Figs. 16 and 37), and the other is that these cysts usually differ from the ordinary retention cysts of the same size in that the walls are thicker, and after the contents have escaped, they stand apart and do not collapse to the same degree as do the others (Figs. 2, 17 and 28). The size of the perforation varies with the amount of trauma done at the time of operation in freeing the ovary. The situation of the perforation is of interest. I have always found it either on the lateral



Fig. 7 (Case 10).—Perforating hemorrhagic cyst of the left ovary with adherent retroflexed uterus. Sagittal section of the pelvis;  $\times \frac{1}{2}$ . The cyst of the left ovary had ruptured, causing adhesions between it and the posterior layer of the left broad ligament and also between the posterior wall of the uterus and the anterior wall of the rectum. The histologic structure of the hemorrhagic cyst is shown in Figures 8, 9 and 10. Sections were not made of the adherent pelvic structures. Therefore, it was not determined whether or not adenoma of the endometrial type was present in these tissues.

surface of the ovary (Figs. 16 and 37) or on its free border (Fig. 28), and have never found it on the mesial surface. Even when adherent to the posterior surface of the uterus, the ovary has been turned upward so that its lateral surface was in contact with the uterus (Figs 37 and 43).

The appearance of the inside of the cyst varies in different specimens and often in different portions of the same specimen. In some instances,

nearly the entire inner surface is rough and brown owing to pigmentation from old hemorrhage. This is often true of the deeper portion of the cyst cavity (Figs. 16 and 17). In others, the lining of the cyst is for the most part smooth and gray, with or without areas of brown pigmentation or elevated red areas due to old or recent hemorrhages in the wall of the cyst. The smaller cysts of this series consisted of only one cavity while some of the larger ones were apparently multilocular with the loculi communicating with one another as though the cyst had ruptured into cystic follicles adjacent to it or there had been a fusion of several hematomas. Savage<sup>3</sup> has called attention to the tendency of "hemorrhagic follicles" to rupture internally into each other.

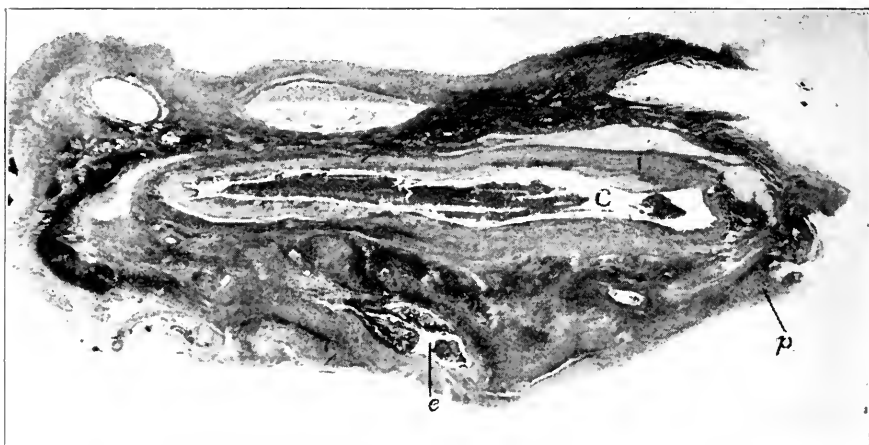


Fig. 8 (Case 10).—Enlargement ( $\times 5$ ) of a stained cross section of the ovary shown in the previous illustration. The cyst *c* is partially collapsed, with some of the "chocolate" contents still in its cavity. The wall of the cyst is for the most part lined by a single layer of epithelium (in places absent) which is low, cuboidal and columnar, and except near the site of perforation, lies directly on the ovarian tissue without an intervening stroma. In a few places, recent subepithelial hematomas are present and also in other places evidence of old hemorrhage as shown by pigmented cells. In the cyst wall near the site of perforation, a cellular stroma is present which contains glandlike structures lined by columnar epithelium, the picture resembling endometrium (Fig. 9). A small cyst or pocket is present lateral to the hemorrhagic cyst in which the lining more nearly resembles typical endometrium (Fig. 10).

Novak<sup>6</sup> has classified the various forms of ovarian hematomas thus: (1) follicular, including graafian follicle and atretic follicle; (2) corpus luteum, and, (3) stromal.

He believes that hemorrhage into atretic follicles is the most frequent form of follicular hemorrhage.

To this classification should be added a fourth variety of ovarian hematoma, namely, one lined wholly or in part by "endometrial tissue." Russell,<sup>7</sup> in 1899, published the report of a case in which uterine mucosa

7. Russell, W. W.: Aberrant Portions of the Müllerian Duct Found in the Ovary, *Bull. Johns Hopkins Hospital* **10**:8-10, 1899.

was found in an ovary. Lockyer<sup>8</sup> (page 328) pictures and describes a specimen of Semmelink and Joslin de Jong. The ovary was adherent to an "adenomyomatous" uterus. There was in the ovary a blood cyst lined in part by "adenomyomatous tissue" and with similar tissue in spaces in the periphery of the ovary. Casler,<sup>9</sup> in 1919, reported an unusual case in which a patient menstruated through the vagina after a conservative hysterectomy in which one ovary was saved. The uterus was removed for an "adenomyoma" which contained stroma but no glands. At the second operation, four years later, the enlarged ovary was removed and it was found to contain cavities lined by "normal uterine mucosa." Cullen,<sup>10</sup> in his recent article, "The Distribution of Adenomyomas Containing Uterine Mucosa," describes three specimens of ovaries containing uterine mucosa, one sent to him by Dr. Charles

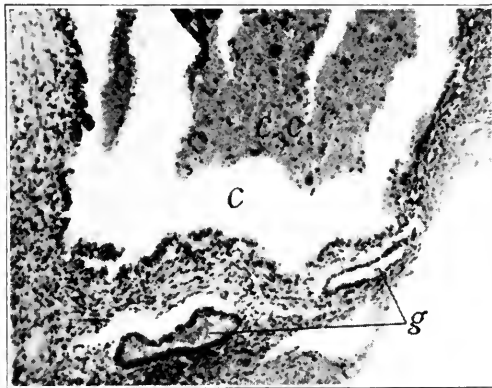


Fig. 9 (Case 10).—Photomicrograph (from another section) of the wall of the cyst *c* shown in Figure 8 near the perforation. This portion of the cyst is lined by a single layer of columnar cells resting on a cellular stroma. Glands (*g*) resembling uterine glands are also present in the stroma. *C* indicates the cavity of the cyst, and *C-C* its hemorrhagic contents. One would have little hesitation in calling this a hematoma of endometrial type and considering that the hemorrhagic contents are probably retained "menstrual" blood.

C. Norris,<sup>11</sup> another by Dr. Otto Schwarz, and the third of his own, the latter occurring in an ovarian cyst lined with a brownish membrane. In all these cases, the histologic picture was similar to that of normal endometrium. In the study of ovarian hematomas to determine whether or not the lining of the hematomas is of endometrial type, it would seem

8. Lockyer, Cuthbert: *Fibroids and Allied Tumors*, New York, The Macmillan Company, 1918.

9. Casler, D. B.: A Unique, Diffuse Uterine Tumor, Really an Adenomyoma, with Stroma, but no Glands. Menstruation After Complete Hysterectomy Due to Uterine Mucosa in Remaining Ovary, *Tr. Am. Gynec. Soc.* **44**:69-84, 1919.

10. Cullen, T. S.: The Distribution of Adenomyoma Containing Uterine Mucosa, *Arch. Surg.* **1**:215-283 (Sept.) 1920.

11. Norris, C. C.: *Am. J. Obst. & Gynec.* **1**:831-834 (May) 1921.

preferable to use as our standard of comparison not normal endometrium but ectopic endometrium in which there is a cyst (hematoma) formation due to the retention of "menstrual blood," similar to the condition in ovarian hematomas. We have abundant opportunity to study the variations in the appearance of the uterine mucosa in the hemorrhagic cysts or cavities, so often found in uterine "adenomyomas." These should be our standards of comparison in the study of ovarian hematomas because the physical conditions are similar. Even in the glandular hypertrophy of the mucosa lining the uterine cavity in which there is dilatation of the glands we may find these dilated glands lined by columnar, cuboidal and even low epithelium (Fig. 5). In the hemorrhagic cysts of uterine "adenomyomas," the epithelium may also be columnar, cuboidal, low, or in places it may be absent. Furthermore, in these cysts, the characteristic "endometrial stroma" may be very thin or even lacking entirely, the epithelium resting directly on the

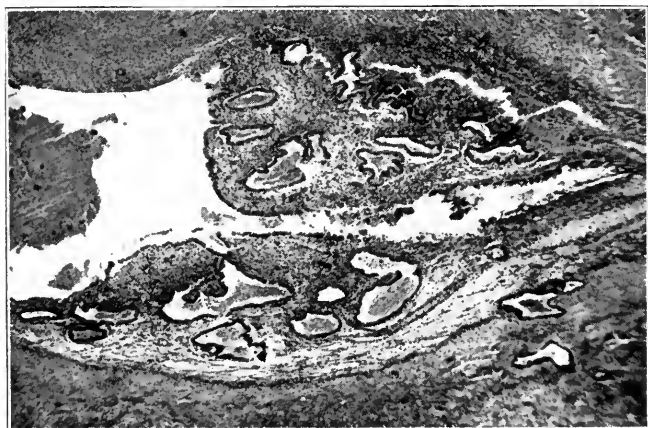


Fig. 10 (Case 10).—Photomicrograph of a portion of the pocket *c* shown in Figure 8. Histologically, the pocket is in part lined by "endometrial" tissue.

tissue of the uterine wall or the "myoma" (Fig. 6). In the ovarian hematomas that I am reporting, the histologic appearance of the portion of the cavities lined by epithelial tissue is identical with that of the uterine hematomas above mentioned except as altered by tissue peculiar to the ovary. These questions naturally arise: What is the source of this epithelium? Are these hematomas primarily of endometrial type or may an ovarian hematoma be secondarily lined by epithelium from another source?

Both Runge<sup>12</sup> and Wolf<sup>4</sup> have demonstrated the "epithelialization" of ovarian hematomas by the invasion of the "surface epithelium of

12. Runge, E.: Ueber die Veränderung der Ovarien bei Syncytralen Tumoren und Blasenmole; Zugleich ein Beitrag zur Histogenese, Arch. f. Gynäk. **69**:33-70, 1903.

the ovary," through the opening caused by the rupture. Runge, by serial sections made through the place of rupture, demonstrated that the epithelium lining the cyst was continuous with that covering the surface of the ovary. Wolf's work confirms that of Runge, and he states that the epithelial cells invading and relining the cavity of the cyst may be low, cuboidal or columnar; when columnar it is due to lateral compression. He also believes that glandlike structures in the underlying stroma arise from a pushing downward of the overlying epithelium.

If these cysts are of endometrial type and if their epithelial lining arises from the invasion of the surface epithelium of the ovary through

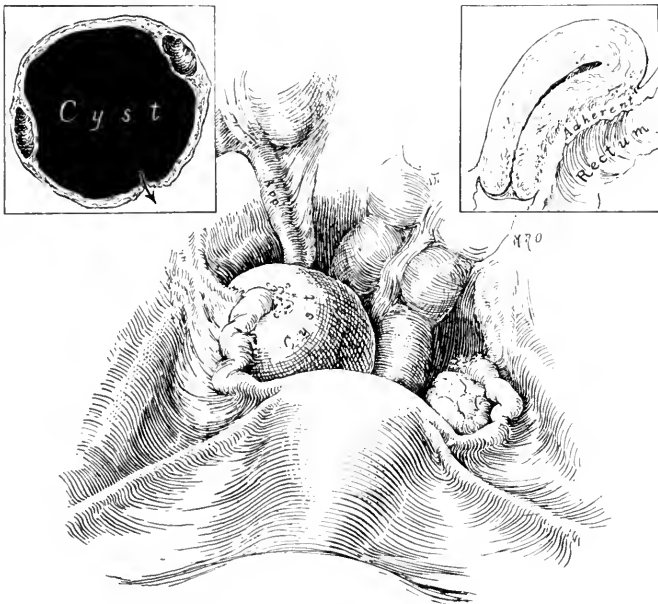


Fig. 11 (Case 5).—Perforating hemorrhagic cyst of right ovary with adherent retroverted uterus and adherent appendix. View of pelvic contents from above;  $\times \frac{1}{2}$ . The cyst of the right ovary had ruptured, causing adhesions between it and the side of the pelvis, and also between the posterior wall of the uterus and the anterior wall of the rectum. The tip of the appendix is firmly held in the pelvis by these adhesions. Only one section was made from the right ovary. This showed that the wall of the cyst in places was lined by cuboidal epithelium resting on ovarian tissue. Sections were not made from the raw areas created by freeing the uterus. Therefore, it was not determined whether or not adenoma of endometrial type was present in these tissues.

the place of rupture, we must conclude that a metaplasia of this epithelium occurs, by which it may not only assume the histologic picture of endometrial tissue but may even function as such. It may be possible that, following the rupture of the hematoma or whatever structure preceded the secondary epithelial invasion, misplaced epithelium of endometrial type was present in the periphery of the ovary at this site and this epithelium was stimulated to become invasive and relined the cavity of the hematoma. We often find glandlike structures

in the ovary, especially in its periphery, which are usually known as "cell inclusions." I believe that some of these glandlike structures are due to misplaced epithelium of endometrial type which under "proper" stimulation might become invasive and actually reline the cavity of the hematoma through the opening caused by the initial rupture, or by hemorrhage into the lumen of the gland they may develop into "endometrial" hematomas. In three patients, recently operated on by me during the menstrual period, small hemorrhagic elevations were noticed on the surface of the ovaries. These were excised or the ovary removed, and in each instance, they proved to be due to hemorrhage



Fig. 12 (Case 9).—Perforating hemorrhagic cysts of both ovaries. View of the pelvic contents from above;  $\times \frac{1}{2}$ . The cyst of the left ovary is the largest of its kind I have seen, approximately 9 cm. in diameter. Both ovarian cysts had ruptured, the right ovary being adherent to the side of the pelvis and the left one to the posterior wall of the uterus, thus sealing their perforations. Only one section was made from each ovarian cyst, these showed that three cysts were in part lined by low to cuboidal epithelium. Pigmented cells, evidence of old hemorrhage, were also present in the walls of the cyst. Sections were not made from the cysts at the site of perforation.

about or into a space lined by tissue of endometrial type. I believe that this tissue was of endometrial type as shown both by its structure and by its function (menstruation).

In most of the specimens which I have examined it has been impossible to determine the exact nature of these cysts before the initial rupture. They may have been endometrial cysts at the start; or they may have resulted from an abnormal condition of a follicle by which a hema-



toma arose in a graafian, or atretic, follicle; or possibly following ovulation, an abnormal corpus luteum developed, due to the invasion of the epithelial tissue as above mentioned. With my present knowledge, I prefer to mention these possibilities rather than make definite statements which later may prove to be incorrect.

The cysts which I have studied histologically, twenty-six in number, may be arranged into three groups.

First, a cyst in which a portion, usually the deeper, is lined by a wavy pigmented "luteal" membrane in various stages of retrogression; while another portion of the cyst, often toward the site of perforation,

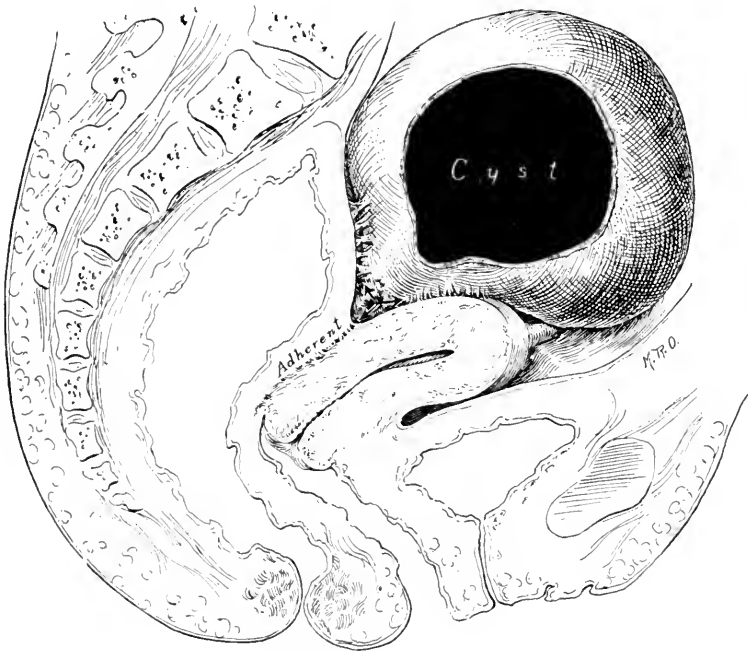


Fig. 13 (Case 9).—Sagittal section of the pelvis shown in Figure 12. The cyst of the left ovary is thin walled, the contents consist of dark hemorrhagic fluid like chocolate syrup. The anterior rectal wall is drawn forward and upward, having been firmly united to the lower half of the posterior wall of the uterus. Tissue was not removed from the posterior wall of the uterus or the anterior wall of the rectum to see whether or not adenoma of endometrial type was present.

is lined by epithelium, low, cuboidal, or columnar, resting on a vascular cellular stroma sometimes containing glandlike structures resembling uterine glands. In this stroma, one finds evidence of recent and also of old hemorrhage. The epithelial portion of the cyst strongly suggests misplaced atypical endometrial tissue both in structure and in function, namely, the evidence of periodic hemorrhage (menstruation). At the junction of the epithelial layer with the "luteal" layer the epithelium

can be seen flattened and riding up over the retrogressing "luteal" membrane (Fig. 20), also described and pictured by Wolf. With the retrogression of the "luteal" layer and the advance of the epithelial lining, the hematoma may be gradually converted into a hematoma completely lined by epithelium of the endometrial type. This group represents either the development of an "endometrial" cyst from the invasion of a follicular hematoma by misplaced "endometrial" epithelium or else it represents the regeneration of the epithelial lining of an "endometrial" cyst after a hemorrhage (menstrual), as indicated by the contents of the cyst, the pigmented "luteal" layer and the lesions in the pelvis. A good example of this group is shown in Figure 17.

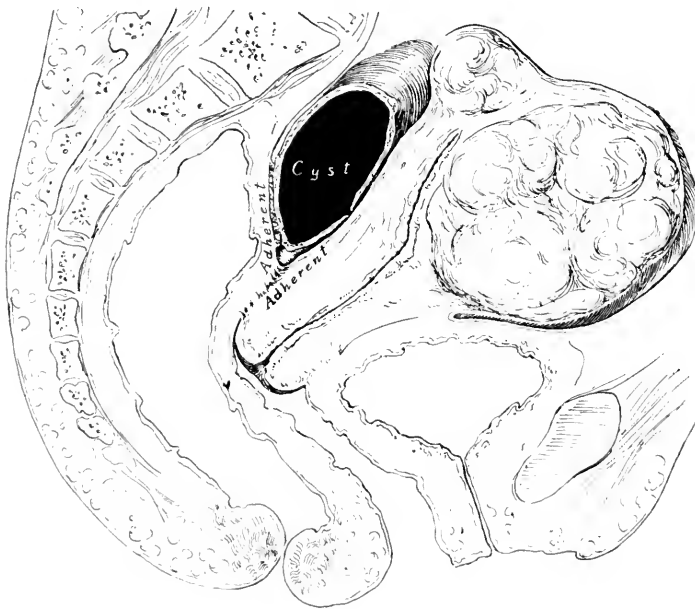


Fig. 14 (Case 8).—Perforating hemorrhagic cyst of left ovary, multinodular myomatous uterus, supravaginal portion of the cervix densely adherent to the anterior wall of the rectum. Sagittal section of the pelvis;  $\times \frac{1}{2}$ . The cyst had ruptured and the perforation was sealed by the posterior wall of the uterus to which the cyst had become adherent. Some of the contents of the cyst had escaped into the culdesac causing dense adhesions between the anterior rectal wall and the supravaginal portion of the cervix. The rectum is drawn upward and forward by these adhesions. Tissue from the posterior wall of the uterus was not examined to determine whether or not adenoma of endometrial type was present.

The second group may represent a later, or even an earlier, stage of the preceding. The cyst is lined by epithelium, low, cuboidal or columnar, often with a narrow, underlying, vascular stroma with occasional glandlike structures, most evident about the site of perforation. The entire cyst is like the epithelial portion of the cysts described in the first group. The picture suggests periodic hemorrhages in the recent hematomas in the subepithelial stroma and in the pigmented

cells in the same situation. A good example of this group is shown in Figure 28. All gradations between the first two groups may be found.

The third group (well shown in Figures 2, 3 and 4), and the smaller one, is more difficult to recognize as an ovarian hematoma of endometrial type. The cyst wall is composed of ovarian tissue which lacks a vascular stroma and in places may also lack a definite epithelial lining. When the latter is present, it is usually low to cuboidal and rests directly on the ovarian tissue. However, tissue of endometrial type is present in pockets in the periphery of the ovary about the perfora-

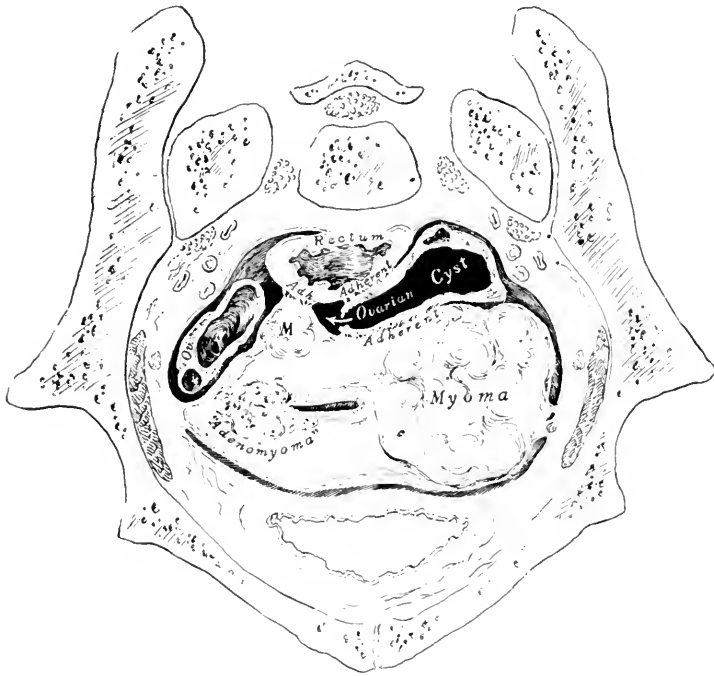


Fig. 15 (Case 4).—Perforating hemorrhagic cyst of the left ovary; multinodular myomatous uterus; “adenomyoma” in the right uterine cornu; adhesions; encapsulated cyst contents in the culdesac. Cross section of the pelvis;  $\times \frac{1}{2}$ . The cyst was badly torn in removing it, and the representation of pelvic contents was drawn from a sketch made just after the operation. Sections were not taken from the raw areas caused by the escape of the contents of the cyst and those made from the cyst were unsatisfactory.

tion. The exact counterpart of the lining of this ovarian hematoma may be found in some of the uterine hematomas occurring in “adenomyoma” of the uterus (compare Figures 3 and 6).

In studying any one of these cysts, certain questions naturally arise regarding the various stages in the development of the cyst prior to the present one and what would be its future stages if it had not been removed. Apparently, the cysts have a definite life history, with

variations, in which they pass through various stages of growth or development to be followed by various stages of retrogression by which the smaller cysts may "disappear" as they are apparently rare after the menopause. It is difficult to determine the duration of their life in any case. I believe it varies greatly in different cases and is not

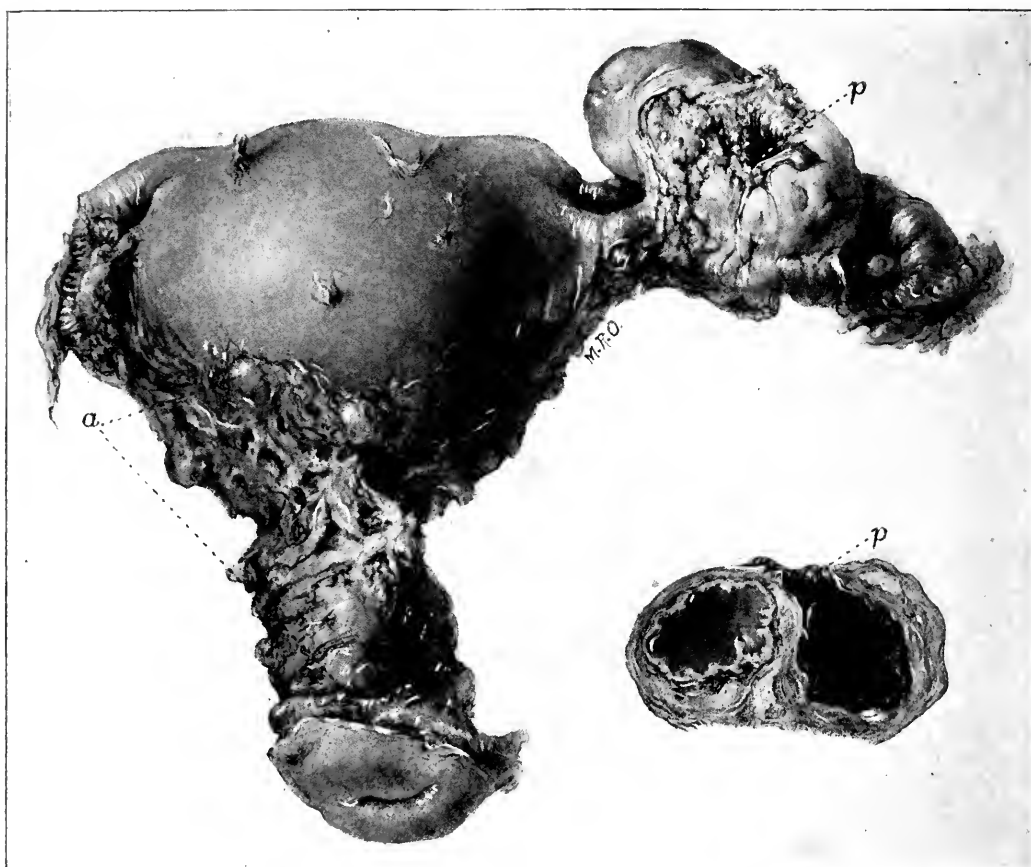


Fig. 16 (Case 21).—Perforating hemorrhagic cyst of right ovary; adenoma of endometrial type of the culdesac invading the posterior uterine wall and uniting it to the rectum. Posterior view of the uterus, right tube and ovary;  $\times 1$ . Ovary is shown turned upward, with perforation on its lateral surface. A raw area is present about the site of perforation due to freeing the ovary from the side of the pelvis to which it was adherent. Longitudinal section of the ovary shows a corpus luteum in the proximal pole and a hemorrhagic cyst in the other. For microscopic sections of the cyst, see Figures 17, 18, 19 and 20. Adenoma of endometrial type, with discrete "adenomyoma" in places, were present in the greater portion of the raw area of the posterior wall of the uterus. Sections through the nodule indicated in the short "arm" of the "pointer" *a* apparently demonstrate the development of "adenomyoma" of the uterus from epithelium deposited on its peritoneal surface by the escape of the contents of the perforating hemorrhagic ovarian cyst into the culdesac (Figs. 21, 22, 23, 24 and 25).

necessarily of long duration. I hesitate to state what I believe their life history to be because I am not sure that I am correct. It is true that we may possibly be dealing with several different kinds of cysts,

but it is much more likely that most of the apparent different kinds represent various stages of growth or of phases (menstrual) in the life history of one variety.

One of the most interesting features associated with the ovaries containing these cysts is the clefts or pockets sometimes simulating small cysts, lined by epithelial tissue. These pockets are small and situated about the perforation, or they may be lateral to it. I have always found them on the lateral surface of the ovary or on its free border. The pockets are lined by epithelium of endometrial type and function; and the type may be more nearly normal than that lining its

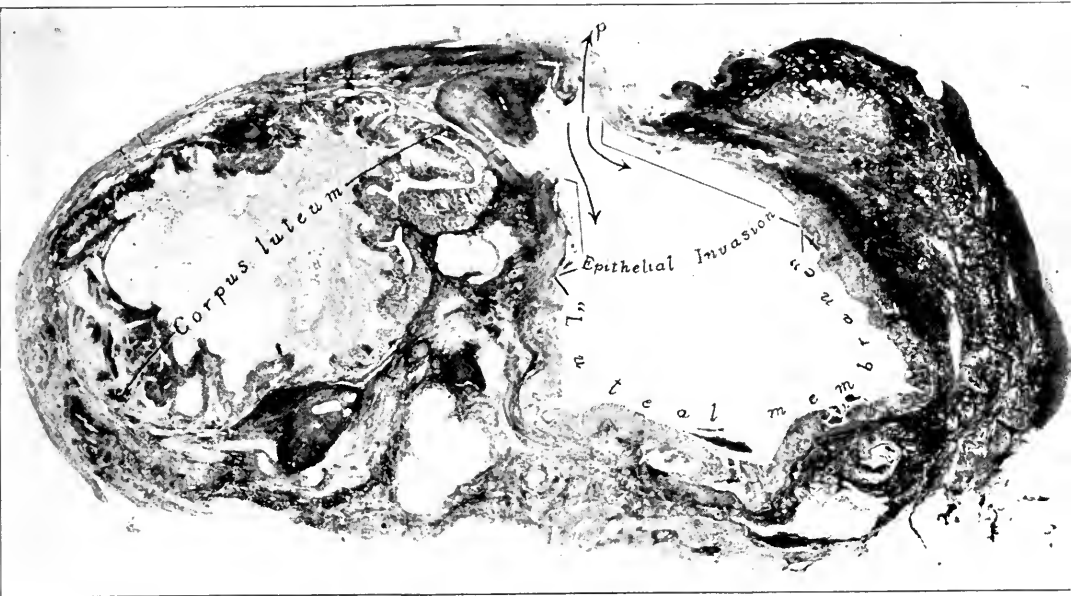


Fig. 17 (Case 21).—Enlargement ( $\times 3$ ) of a stained longitudinal section of the ovary. The deeper portion of the hemorrhagic cyst is lined by a thick, wavy, pigmented membrane. The rest of the cyst (toward the perforation) is lined by a single layer of columnar cells separated from the underlying ovarian tissue by a vascular stroma (Fig. 19). As the latter cyst lining approaches the pigmented "luteal" layer, its surface epithelium (now cuboidal or flattened) extends over the surface of the retrogressing "luteal" layer (Fig. 20). Tissue resembling typical endometrium (Fig. 18) is present both in the torn ovarian tissue within the perforation and in depressions on the surface of the ovary outside. Two interpretations of the picture could be made: first, following the initial perforation of the ovarian hematoma, epithelium of endometrial type situated in the ovary at the site of perforation was stimulated to invade the cyst and is gradually relining its cavity and converting it into an "endometrial" cystoma; or secondly, it represents the regeneration of the epithelial lining of an endometrial cyst after hemorrhage as indicated by the contents of the cyst, the pigmented "luteal" layer and the lesions in the pelvis.

associated hematoma (Figs. 4, 10, 30 and 58). Both the hematoma and the clefts or pockets are apparently part of the same process. The stimulus which causes the epithelial invasion of the hematoma or the development of an "endometrial" cyst also apparently causes the development of the clefts or pockets.

All phases of the hemorrhagic (menstrual) cycle may be observed in these hematomas and often in one hematoma. I judge the process of repair is not so rapid as in the mucosa of the uterine cavity, and the repeated hemorrhages may eventually destroy the cyst. The same hemorrhagic cycle may take place in the clefts or pockets as in the cyst proper. A "premenstrual" condition is well shown in Figure 28, as the patient was operated on the day that menstruation was due. Hemorrhage is present in the entire subepithelial stroma of the larger cyst and likewise in the clefts and pockets in the periphery of the ovary. All of the "endometrial" tissues of the ovary had responded to the "menstrual" impulse.

Evidence of old hemorrhage may be found in the pigmented cells in the subepithelial stroma of some of the cysts. As the "menstrual" process in these cysts is similar to that of the uterine mucosa the blood escapes into the cyst cavity by the rupture of the subepithelial hematomas. One can also see how "menstrual" blood might at times

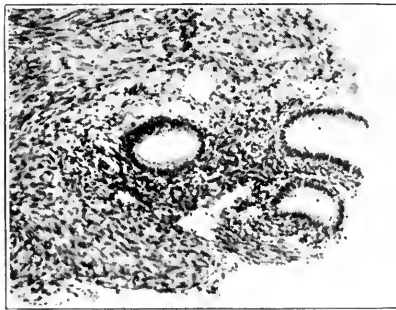


Fig. 18 (Case 21).—Photomicrograph of tissue in the wall of cyst at the site of perforation. Histologically, it resembles endometrium.

escape into the pelvis; either leak by the site of the original perforation; from a secondary perforation or from the endometrial tissue in the clefts or pockets. The "menstrual" blood escaping into the peritoneal cavity may carry with it some of the epithelium lining the cyst cavity, or similar tissue may escape from the endometrial pockets in the periphery of the ovary about the perforation. This epithelium may become implanted in the culdesac or other portions of the pelvis and there give rise to other foci of "endometrial" tissue. The mechanism of secondary perforations of the cyst can be easily explained by a subepithelial hematoma developing in a thin portion of the cyst, the rupture of the hematoma so weakening the wall of the cyst that a perforation would occur.

*B. The Adhesions Arising from the Escape of the Contents of These Cysts.*—I judge that the amount of the cyst contents escaping into the peritoneal cavity is usually small, and clinically, it is rarely accompanied by any subjective symptoms.

The adhesions occur about the ovary at the site of perforation and in different portions of the pelvis where there are naturally folds or pockets in which such material would be apt to lodge, as has been previously stated in this paper. They vary greatly in degree and extent and may be slight, as those resulting from a mild peritonitis of tubal origin or so dense as to simulate malignancy.

Savage<sup>3</sup> has described these adhesions and believed that they arose from a reactive inflammation due to the escape of the hemorrhagic contents of the cyst. Hedley<sup>5</sup> has also described them and mentioned one case in which there was such a marked inflammation of the cellular tissue of the culdesac as to lead to a diagnosis of cancer of the rectum. He obtained a pure culture of *Staphylococcus pyogenes albus* in two

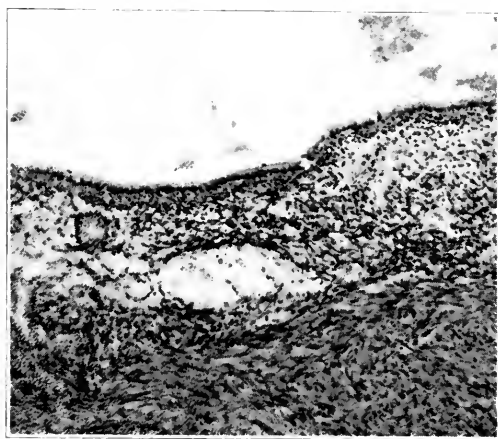


Fig. 19 (Case 21).—Photomicrograph of the wall of the cyst being relined or regenerated by the invasion of epithelium from the periphery of the ovary through its perforation or from epithelium not removed by the hemorrhage (Fig. 17). Histologically, the portion of the cyst marked "epithelial invasion" (Fig. 17) is lined by a single layer of epithelium with a vascular underlying stroma, in places containing pigmented cells evidence of past hemorrhages and in other places fresh blood evidence of a recent hemorrhage.

cases and suggests this organism as a cause. Both Savage and Hedley call attention to the lack of gross evidence of tubal inflammatory disease.

I began to study the cause of these adhesions in the year 1918. Cultures were made both from the cyst contents and also from the pelvic cavity after freeing the adherent structures. Eight cases have been studied in this manner, and the cultures were sterile in all. Agar and blood serum were used as culture mediums. Dr. George S. Graham, in 1918, injected some of the material, obtained aseptically from these cysts, into the peritoneal cavity of rabbits. It caused adhesions. This experiment was performed only in a few instances and was not controlled by injecting normal human blood.

I had planned to present a paper at the last meeting of the American Gynecological Society describing these cysts and the adhesions resulting from them. Some of the illustrations in the present paper were made from sketches prepared for the paper I had planned to read a year ago. At that time I believed that these cysts were "endometrial" hematomas and that the adhesions arose from the escape of "menstrual" blood into the peritoneal cavity. It differed from normal blood in that it was very irritating, and I thought that the irritation was probably due to some "digestive ferment." I still believe that these cysts are hematomas of endometrial type and their contents may be very irritating to the peritoneum. Up to that time, I had observed three patients with these cysts in which an "adenomyoma" of the posterior uterine wall was also present (Cases 2, 3 and 6 of this paper). The "adenomyomas"

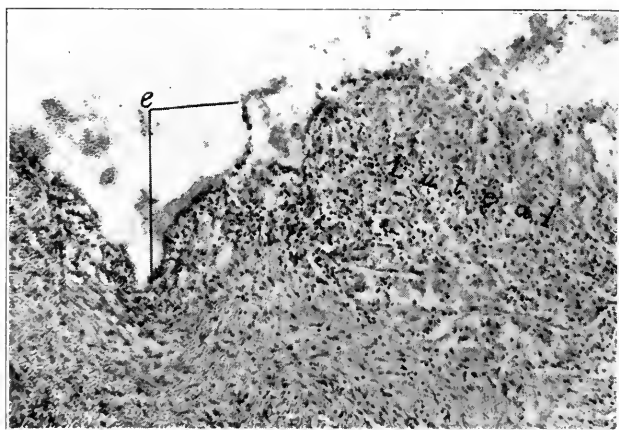


Fig. 20 (Case 21).—Photomicrograph of the wall of the cyst (Fig. 17) at the junction of the "epithelial" and "luteal" lining. The epithelial cells lining the portion of the cyst shown in Figure 19 have become cuboidal and flattened and can be seen extending (growing) over the retrogressing "luteal" layer. The "luteal" layer lacks an epithelial covering; and also the fibrous tissue lining found in typical corpus luteum hematomas. In time this cyst might be completely lined by "endometrial" epithelium as those shown in Figures 28 and 39.

had "apparently" extended through the peritoneal surface of the posterior uterine wall and obliterated the culdesac, fusing the uterus with the rectum. The "adenomyomas" were apparently not continuous with the mucosa of the uterine cavity. I considered these three cases as further proof that the ovarian hematomas associated with them were of endometrial type. Developmental anomalies are often multiple and at that time I regarded these as instances of misplaced "endometrial" tissue in both the ovary and the posterior wall of the uterus. The adhesions between the uterus and the rectum in these three cases were identical in character with other cases of perforating hemorrhagic cysts in which "adenomyoma" had not been observed. The tissue



involved in the adhesions in the latter cases had not been examined under the microscope and therefore adenoma cannot be excluded. I thought that the adhesions in the three cases arose, at least, in part, from the rupture of superficial subperitoneal "adenomyomatous" spaces of the uterine wall which had become overdistended with menstrual blood. This also afforded an opportunity for the invasion of the anterior rectal wall and offered an explanation of the development of "adenomyoma" in the rectogenital space. Sections made of the posterior uterine wall show the adenomyomatous spaces which had been torn open in freeing the uterus from the rectum (Fig. 63).

During the last year, I have examined microscopically all tissue involved in these adhesions except when conservative work was done. Adenoma of the edometrial type was found in this tissue in ten of the fourteen patients with perforating hemorrhagic cysts of the ovary

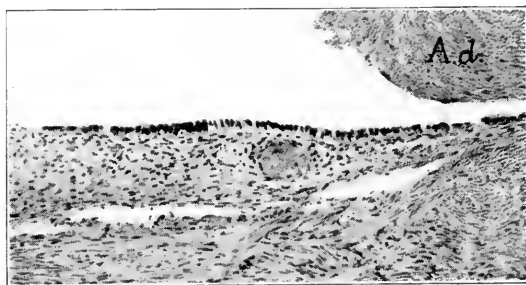


Fig. 21 (Case 21).—Photomicrograph of the posterior surface of the uterine wall near the nodule indicated in Figure 16. The surface of the uterus is here covered by columnar epithelium with an underlying vascular stroma similar to that shown in the "relining" of the ovarian hematoma by the "epithelial invasion" (Fig. 19). "Ad." represents an adhesion on the surface of the uterus. This change in the surface of the uterus is due to the escape of the contents of the cyst into the culdesac. Does it represent an epithelial implantation carried with the contents of the cyst or an "endothelial" metaplasia from the "specific" irritation of the cyst contents on the peritoneal covering of the uterus? I believe the former.

operated on by me from May 1, 1920, until May 1, 1921. In the four cases in which it was not found, the adhesions were slight, conservative work was done and the tissue involved outside the ovary was not removed. During the month of May of this year, I operated on four patients with these cysts, and in all four adenoma of endometrial type was found in the pelvic tissue outside the ovary. These four specimens have not been sufficiently studied to be included in this paper. Of the twenty-three cases reported in this paper, pelvic adenoma of endometrial type was found in thirteen. In the remaining ten it was not found. I believe it might have been found in many, and possibly in all, of these ten cases had the tissue involved in the adhesions been carefully studied. It was examined microscopically in only one of these, and in that one not thoroughly enough to exclude adenoma.

All of the twenty-three cases reported in this paper were of value in the study of the clinical features of this condition, and in most of them a satisfactory histologic examination of the ovaries was made.

Only the thirteen cases in which the tissue involved in the adhesions was examined histologically and adenoma was found will be considered in the following discussion.

These cases may be grouped according to the distribution of the adhesions as follows:

1. Extensive adhesions in the culdesac obliterating the lower portion of it and uniting the cervix or the lower portion of the uterus to the rectum; with adenoma of the endometrial type invading the cervical and the uterine tissues and probably also (but to a lesser degree) the anterior wall of the rectum.

2. Adhesions between the uterus and the rectum with multiple discrete invasions of the posterior uterine wall by adenoma of the endometrial type.

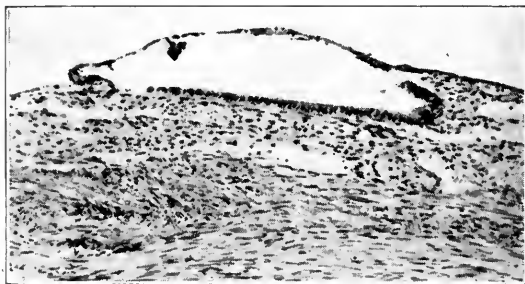


Fig. 22 (Case 21).—Photomicrograph from another portion of the section shown in Figure 21. The epithelium is "sinking" into the underlying vascular stroma forming a dilated gland or bleb, apparently the second step in one form of development of adenoma of the endometrial type on the surface of the uterus.

3. Adhesions in the normal peritoneal folds associated with the development of adenoma of endometrial type, as, about the uterosacral ligaments; on the posterior surface of the broad ligaments between the tube and the ovarian ligament; on the anterior surface of the broad ligament between the tube and the round ligament, and in the vesico-uterine reflection of peritoneum.

4. Discrete nodules of adenoma in the wall of the rectum and sigmoid.

To describe in detail the conditions found in these thirteen cases would be but a repetition of the legends accompanying the illustrations and it would not be done so well.

Group I. Extensive adhesions in the culdesac uniting the cervix or uterus or both to the rectum with adenoma of endometrial type, is represented in nine cases (Cases 2, 3, 6, 12, 13, 15, 19, 21 and 23).

In this group the material from the cyst escaping into the culdesac caused adhesions between the cervix or uterus and the rectum. The adenoma of endometrial type apparently develops on the surface of the adherent structures (Figs. 21, 22, 23 and 24), between the adhesions, especially on the posterior surface of the uterus or cervix, and later may become invasive. The cervix or uterus is invaded more often, and usually to a greater extent than the other adherent structures (Figs. 59, 61, 36, 26, 34, 42, 62 and 64). Possibly uterine tissue "attracts" the adenoma; it is better suited for its growth. In some instances, the adenoma penetrates the uterus with very little reaction on the part of the tissue involved (Fig. 59). In others, the reaction is great, causing a diffuse or localized thickening, namely, an "adenomyoma" (Figs. 38, 44, 62 and 64). Adenoma may also be present in the tissues which are adherent to the ovary (Figs. 44, 45 and 51).

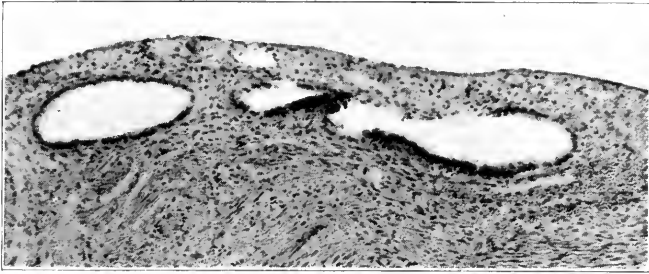


Fig. 23 (Case 21).—Photomicrograph from another portion of the section shown in Figure 21. The dilated glands are completely embedded in the vascular stroma, which is thicker, apparently a third stage in one form of development of adenoma of endometrial type on the surface of the uterus.

The epithelial lining of the ovarian hematomas, of the clefts and pockets on the surface of the ovary is similar to that of the adenoma in the tissues to which the ovary is adherent and in the adherent structures in the culdesac (Figs. 39, 40 and 41). The process in all is apparently the same whether in the ovary, in the cystlike cavities of the adenoma of the uterus, cervix, large intestine or in any other tissue, but is altered by the tissues involved and by physical factors caused by the retention of "menstrual" blood.

The question naturally rises, Which is primary? The study of my material has convinced me that the ovary is the primary site. Two methods of extension of the "endometrial" adenoma must be considered. First, extension, of the growth by continuity, and in some of the specimens, this may have occurred, and the second is by the implantation of epithelial cells carried with the contents of the cyst or from the epithelial clefts and pockets in the ovary. The implantation is

analogous to the implantation of papilloma and cancer in the culdesac from the rupture of ovarian cysts containing these growths. The question of the origin of these secondary growths from metaplasia of the peritoneal endothelium due to the irritating action of the contents of the cyst will be considered later.

Group II. Peritoneal adhesions with multiple localized invasions of the uterine wall by adenoma.

This phenomenon was also observed in one of the cases of Group I (Case 21, Fig. 25). It was well demonstrated in Case 17, in which discrete "adenomyomas" were found in the posterior uterine wall beneath and about the adherent left ovarian hematoma (Figs. 44 and 46) and also the adenoma invading the uterine wall beneath the adherent right ovarian hematoma (Figs. 44 and 45).



Fig. 24 (Case 21).—Photomicrograph from another portion of the section shown in Figure 21. There is a marked hypertrophy of both the glands and the stroma forming an elevation on the surface of the uterus. Columnar epithelium is present on the surface *e* as in Figure 21. This picture apparently represents a still later stage of development of the adenoma and is similar to the condition shown in Figure 41 (Case 15).

Group III. Adhesion in the normal peritoneal folds of the pelvis associated with the development of adenoma of endometrial type in this tissue, as, about the uterosacral ligament; on the posterior surface of the broad ligament between the tube and ovarian ligament; on the anterior surface of the broad ligament between the tube and the round ligament; in the vesico-uterine reflection of peritoneum and other similar folds where the contents of the ovarian cyst would be apt to lodge. There were two cases in this group, Cases 20 and 22. The illustrations, with their legends, of the specimens from these two cases

picture the conditions found better than any verbal description (Case 20, Figs. 71, 73 and 74, and Case 22, Figs. 65, 67, 68 and 69). There were three interesting conditions found in the specimens of these two cases.

One is the lesion present about the left uterosacral ligament in Case 20 (Figs. 71 and 72). There is a localized thickening of the peritoneum with puckering about its edges, and in this thickened area can be seen small pigment elevations, the surface of small cysts containing "old blood" (Fig. 72). Histologically, these cysts are small hematomas of endometrial type (Fig. 74). The second lesion is that occurring in definite peritoneal folds where the surfaces are adherent



Fig. 25 (Case 21).—Photomicrograph from another portion of the same section as the preceding (lower power). *B* is the small dilated gland or bleb shown in Figure 22. At 1 is the remains of epithelial tissue which had been almost completely "rubbed off" in removing the uterus. 1, 2, 3, 4 and 5 represent the invasion of the uterine wall by the adenoma. There is a marked (reaction) hypertrophy of the uterine tissue forming an "adenomyoma." This represents the final stage in the origin of "adenomyoma" of the uterus from epithelium deposited on its surface from the contents of a perforating hemorrhagic cyst of the ovary.

and an adenoma of endometrial type has developed (Figs. 65, 67 and 68). The adenoma developing in the adherent fold of peritoneum between the left round ligament and the anterior surface of the broad ligament had invaded the round ligament giving rise to an "adenomyoma" of that structure (Fig. 69). The third lesion is still more interesting, that is, blebs or small peritoneal cysts, some containing blood, scat-

tered over different portions of the specimen especially about the lesions in the adherent peritoneal folds (Fig. 68). Histologically many of these blebs are cystomas of endometrial type (Fig. 70). These blebs or cysts are very similar to the one shown in a pocket on the surface of the ovary near the perforation of the hematoma (Case 23, Fig. 50), and also in the development of adenoma on the surface of the uterus (Case 21, Fig. 22). The advocates of the serosal theory of the origin of adenomyoma would look on these specimens as supporting their views on the subject. A full discussion of this phase of the subject may be found in Lockyer's<sup>8</sup> work on fibroids and allied tumors, in his presentation of the serosal theory and his chapter on extra-uterine "adeno-



Fig. 26 (Case 21).—Sagittal section of the pelvis showing the relation of the culdesac adenoma of endometrial type to the uterus and rectum prior to operation;  $\times \frac{1}{2}$ . The adenoma arising in the culdesac "due to the escape of the contents of the cyst" has invaded the posterior wall of the uterus forming an "adenomyoma" and has united this portion of the uterus to the rectum posteriorly. One can see how this growth might extend posteriorly through the wall of the rectum or down between the rectum and vagina or through the vagina presenting in the vaginal vault behind the cervix as in Figure 52, Case 24.

myoma." On pages 295 and 296, Lockyer expresses the following views of the advocates of this theory: "Heterotopy of serosal epithelium is the probable explanation of the existence of the epithelial spaces and cysts in most of the extra-uterine swellings found between the rectum and genital tract," and again he states that "it has also been conclusively shown that the connective tissue which surrounds the 'endothelial' inclusions can be excited to hyperplasia which causes it to assume the characteristic histological features of the stroma of the uterine mucosa."

Group IV. Discrete nodules of adenoma in the wall of the rectum or sigmoid.

These occurred in two cases (Cases 12 and 19). In Case 12 it was situated in the anterior wall of the rectum back of the adherent uterus (Fig. 62). It was distinctly palpated on rectal examination prior to the operation. The rectal mucosa was freely movable over it. It was also palpated during the operation but was not excised. A positive statement cannot be made as to whether or not adenoma was present. The patient was operated on, June 5, 1920. I examined her, May 23, 1921, and was able to detect it; but it had decreased in size

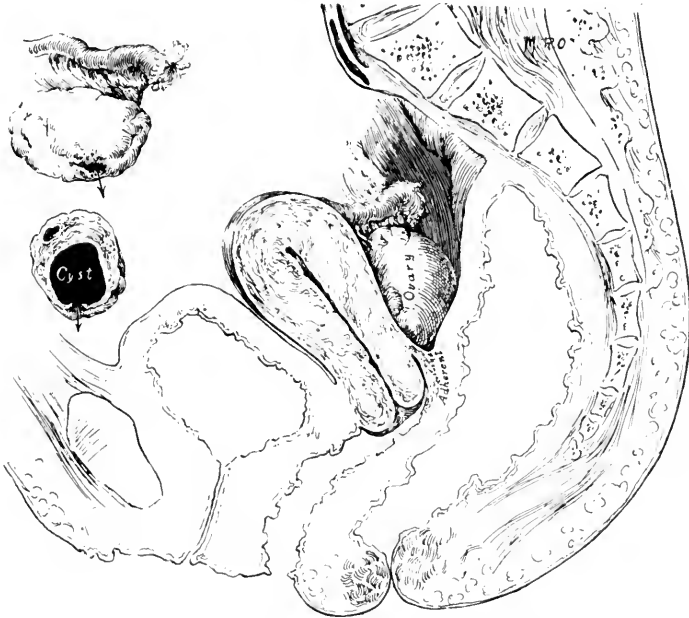


Fig. 27 (Case 13).—Perforating hemorrhagic cyst of the right ovary; ovary prolapsed and adherent; anterior wall of the rectum drawn forward by adhesions between it and the pelvic portion of the vagina. Sagittal section of the pelvis ( $\times \frac{1}{2}$ ) showing the condition found at the first operation, June 28, 1920. Prior to the operation a small thickened area was palpated in the culdesac between the cervix and rectum. At operation, the right tube and ovary and the appendix were removed. Before leaving the hospital this thickened area was detected, and I realized that I had probably overlooked an adenoma of the endometrial type in the culdesac.

probably due to the cessation of ovarian function, as both ovaries and the entire uterus had been removed. The second case (Case 19) was even more interesting. In addition to the adenoma of endometrial type of both ovaries (Fig. 54), and the posterior uterine wall (Figs. 55 and 59), two distinct nodules were palpated in the sigmoid. The upper one was not in contact with the adhesions about the ovaries and the uterus. The upper nodule was the larger and was excised, and the intestine was repaired by an end-to-end suture. Sections of this nodule showed

that the adenoma had extended through the wall of the intestine into the submucosa and there formed small cysts dilated with "menstrual" blood. Adenoma of endometrial type was found on the serous surface of the sigmoid beneath an epiploic appendage and in all the coats of intestine to, and including, the submucosa. Apparently some of the contents escaping from the ovarian hematoma had carried with them some of its epithelium, which was deposited on the surface of the sigmoid and later invaded it. The further description of this case will be reported in another paper. The lower and smaller nodule was not excised. The patient made a satisfactory recovery and so far has remained well. I am waiting with great interest to see whether

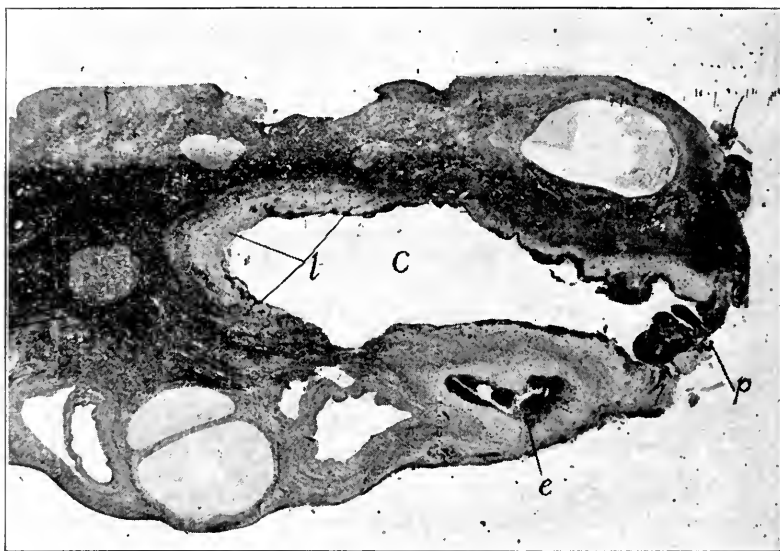


Fig. 28 (Case 13).—Enlargement ( $\times 5$ ) of a stained cross section of the ovary through the site of perforation. Patient expected to menstruate the day of the operation. It, therefore, represents a "premenstrual" condition. The chief features of interest are the larger collapsed hemorrhagic cyst *c*, the small cyst or pocket *e* (Fig. 30) and the ovarian tissue about the site of perforation *p* (Fig. 32). The wall of the cyst *c* is lined by epithelium, for the most part cuboidal, in places columnar, with a cellular stroma containing recent (premenstrual) hemorrhage which appears black in the picture. The columnar epithelium is most marked near the site of perforation where definite glandlike structures are present resembling uterine glands in cross section (Fig. 29).

or not the "adenoma" left in the sigmoid will cause her any further trouble. Both ovaries and the entire uterus were removed and I hope and expect that the cessation of ovarian function will cause any adenomatous tissue which was left in the pelvis to atrophy.

I believe that a large percentage, and possibly all, of the ovarian hematomas reported in this paper were of endometrial type. The microscopic findings in all those examined showed in places a lining



which resembled the lining of hematomas found in "adenomyomas" of the uterus, which apparently had arisen from the mucosa of the uterine cavity. The most typical endometrial formation was found in the portions of the hematomas about the site of perforation and in pockets or clefts in the periphery of the ovary about the same site. This would be expected, as in these situations the epithelial growth is not subjected to the pressure which is present in the hematoma proper. The hemorrhagic feature of these cysts is similar to that of menstruation both in its gross manifestations and in the presence of subepithelial hematomas in the lining of the cyst, with evidence of rupture into its cavity. The hematomas manifest their activity during the menstrual life of the patient as does also the uterine mucosa. In two patients operated on at the time of the menstrual period, one the day that menstruation was due (Case 13, Fig. 29) and the other the last day

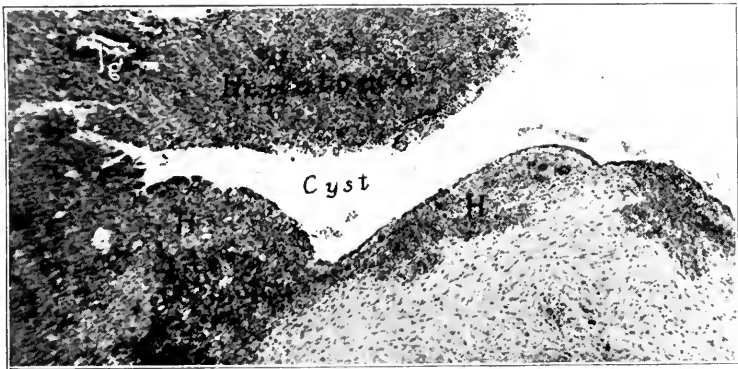


Fig. 29 (Case 13).—Photomicrograph of the wall of the cyst shown in Figure 28, c, near the site of perforation. The cyst is lined by cuboidal and columnar epithelium with moderate and extensive subepithelial hemorrhage (premenstrual). A structure resembling a uterine gland is present at *g*. The cyst is an ovarian hematoma of endometrial type.

of menstruation (Case 19, Fig. 57), the histologic changes in the ovarian "endometrial" tissue corresponded to the phase of the menstrual cycle indicated by the menstrual history of the patient. The contents of the ovarian hematomas resemble old menstrual blood. The most important evidence that these ovarian hematomas and clefts or pockets are of endometrial type is the secondary development of adenoma of endometrial type in the tissues or structures which have become "infected" by material escaping from them. The adenoma in these secondary pelvic foci may more closely resemble normal uterine mucosa than the original ovarian condition and may, in importance, overshadow the latter. "Menstruation" occurs in these pelvic foci and they may be the source of a further extension of the growth, just as it extended from the ovary.

From the standpoint of its origin, "adenomyoma" of the uterus may be divided into at least two groups:

1. The generally recognized group in which the growth has apparently arisen from an invasion of the uterine wall by the mucosa lining the uterine cavity, namely, invasion from "within" the uterus.

2. "Adenomyoma" arising from the invasion of the serous surface of the uterus by adenoma of the endometrial type secondary to adenoma of the ovary, namely, invasion from "without" the uterus. Histologically, the two tumors are identical. The advanced stage of the latter may very closely resemble the former in its gross appearance (Figs. 62 and 64). I presume that it is possible for the adenoma arising on the surface of the uterus to penetrate the entire wall and even reach the mucosa lining the uterine cavity.

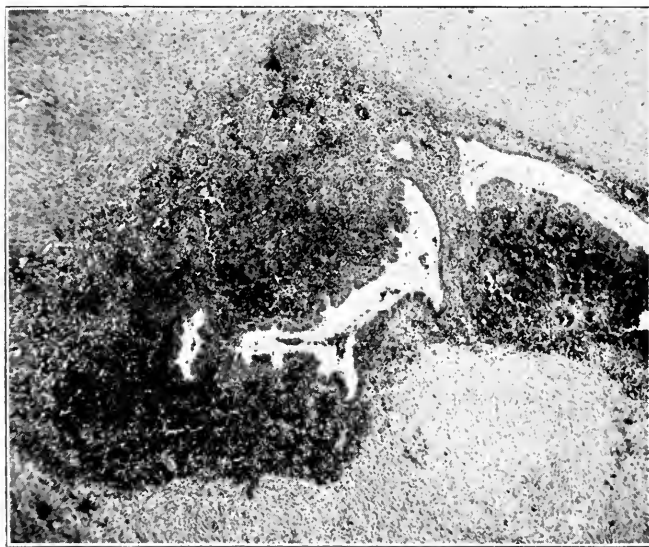


Fig. 30 (Case 13).—Photomicrograph of a portion of the small pocket shown at *c* (Fig. 28). The pocket is lined by columnar epithelium with extensive "premenstrual" hemorrhage in the underlying stroma (appearing black). The pocket is lined by tissue of endometrial type.

I do not know whether or not there is a third group of "adenomyoma" arising from misplaced endometrial tissue in the uterine wall or by invasion from "without" from other sources than the ovary.

Granted that these ovarian hematomas may give rise to secondary growths of adenoma of endometrial type in the pelvis, this question naturally arises, Are all ectopic pelvic adenomas of endometrial type secondary to a similar condition in the ovary? I cannot answer this question. The origin of "adenomyoma" of the uterus from the mucosa of the uterine cavity has just been mentioned. Do we find these

hematomas of the ovary in all other instances of ectopic pelvic adenoma of uterine type? In the thirteen cases of ectopic adenoma reported in this paper, hematoma of the ovary or ovaries in various stages of development and retrogression were found in all, and also in the four patients operated on by me during the month of May of this year and not included in this report. During the year, May 1, 1920, to May 1 1921, I operated on two patients with pelvic adenoma of endometrial type without gross evidence of hematoma of the ovaries. In both instances, a small area of thickening of the peritoneum was found in the culdesac. In this area, small cysts were present which were lined by columnar epithelium and a stroma resembling endometrial tissue—conditions similar to that shown in Figs. 71, 72 and 74. There was a puckered area on the lateral surface of one of the ovaries in



Fig. 31 (Case 13).—Photomicrograph of a dilated "gland" of endometrial type in the periphery of the ovary just above the pocket *e* (Fig. 28). Premenstrual hemorrhage (*H*) is present in the stroma about the "gland." All the "endometrial" tissue in the ovary had apparently reacted to the "menstrual" impulse.

each case, which on microscopic section showed a space in the periphery of the ovary lined by columnar epithelium and stroma resembling endometrial tissue. These spaces of endometrial type could be interpreted as the remains of an "endometrial" hematoma in which nearly complete retrogression had occurred or "endometrial" pockets or clefts which had functioned, namely, had menstruated, and the secondary pelvic adenomas had arisen from them. From my studies, I am inclined to consider them possibly as either one or the other of these. It is also possible that their origin was independent of the ovaries.

A review of the reported cases of ectopic "adenomyoma" in the literature is of little value in determining their relation to ovarian hematomas as the writers were especially interested in the "adeno-

myoma" and probably paid very little attention to the condition of the ovaries unless they were strikingly abnormal. Sammelink and Joslin de Jong's case (reported by Lockyer and already referred to) in which the "adenomyoma" of the uterus had "invaded" the ovary would admit of a reverse interpretation and also a similar case (Case 6) reported by Cullen.<sup>10</sup> In Mahle and MacCarty's<sup>13</sup> case of "adenomyoma" of the sigmoid from the Mayo Clinic, "tarry" cysts of both ovaries were found. In the description of Cullen's<sup>14</sup> reported cases of "adenomyoma of the rectovaginal septum" an occasional reference is made to the fact that a "corpus luteum cyst" was found in one or both ovaries (four of his eighteen cases). Further studies alone will determine to what extent ovarian hematomas are responsible for the development of pelvic adenoma of endometrial type and by them we will also be able to



Fig. 32 (Case 13).—Photomicrograph of a "gland" of endometrial type in hemorrhagic tissue about the site of perforation *p* of the cyst shown in Figure 28. Such a gland as this might become detached during "menstruation" and, escaping into the culdesac, give rise to a secondary growth of endometrial type.

determine which lesions are caused by the epithelial tissue carried with the contents of the cysts and which ones by the irritating action of the contents aside from this epithelial tissue. There is such a great variation both in the invasiveness of the pelvic adenomas and also in their finer histologic appearance that one wonders whether they are all the same. These are all problems for further study.

13. Mahle, A. E., and MacCarty, W. C.: Ectopic Adenomyoma of Uterine Type (A Report of Ten Cases), *J. Lab. and Clin. Med.* **5**:218-228 (Jan.) 1920.

14. Cullen, T. S.: Adenomyoma of the Rectovaginal Septum, *J. A. M. A.* **62**:835-839 (March 14) 1914; Adenomyoma of the Rectovaginal Septum, *ibid.* **67**:401-406 (Aug. 5) 1916; *Bull. Johns Hopkins Hospital* **28**:343-349 (Nov.) 1917, and Footnote 10.

## CLINICAL FEATURES OF TWENTY-THREE CASES

As has been mentioned earlier in this paper, this condition is a disease which develops during the menstrual life of women, especially from 30 years of age until the menopause. Only two of the patients were under 30, the youngest being 26. None had passed the menopause. The oldest was 47 years old. Twelve of the patients were from 30 to 40 years of age and nine from 40 to 47 years, inclusive. The age incidence corresponds to that of myoma of the uterus.

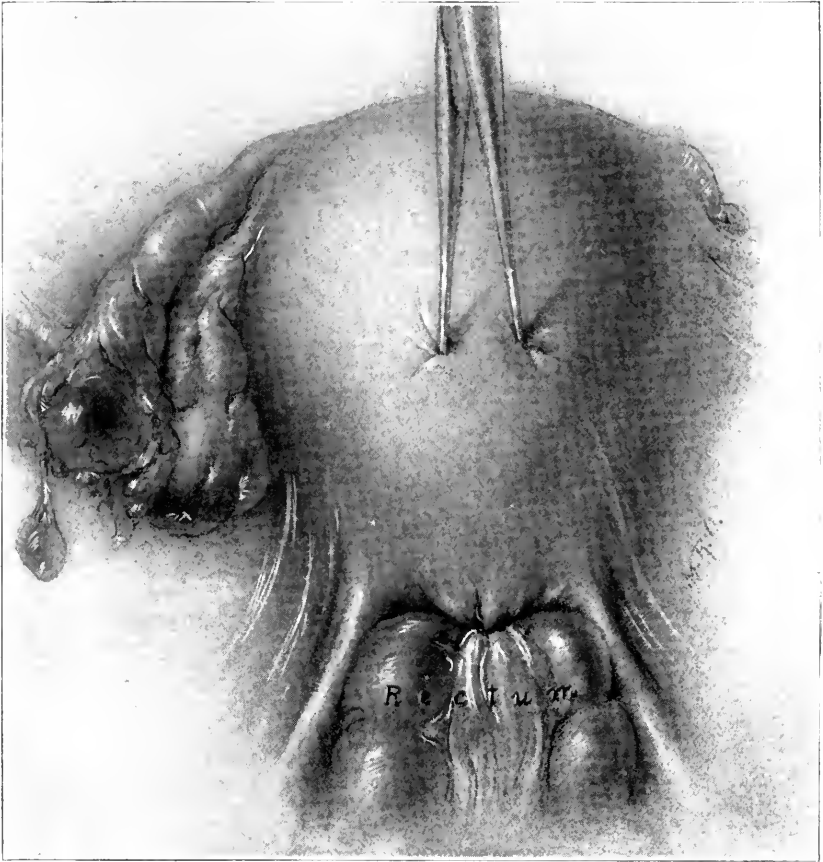


Fig. 33 (Case 13).—Condition found at the second operation, March 21, 1921. On drawing the uterus upward, the anterior wall of the rectum is carried with it as it is fused with the posterior wall of the cervix (Fig. 34).

Of the married women, fifteen in number, nine had never been pregnant. Of the six who had borne children, only three had had more than one. The shortest time that had elapsed since childbirth in any of these cases was five years. It would seem that this condition is likely to occur in women who were sterile; or if they had borne children, there was a subsequent history of sterility probably in part due to the age of the patient.

The most important factors in the origin of the subjective symptoms in these cases are the extent and situation of the adhesions and also other pelvic diseases which may be present. In some instances, other pelvic diseases are the more important conditions and in other cases the condition resulting from these cysts may predominate.

We are likely to find associated with these cysts any pelvic condition occurring in women from 30 years of age to the menopause. There are two possible exceptions in which a common age incidence does not



Fig. 34 (Case 13).—Adenoma of endometrial type involving the posterior wall of the cervix and the adjacent wall of the rectum. Sagittal section of the uterus removed at the second operation. The bottom of the culdesac has been obliterated by the adhesions resulting from or associated with the adenomatous growth and fusing the anterior rectal wall to the posterior wall of the cervix and the vagina. The adenomatous spaces have extended about half way through the cervix toward the cervical canal and have only slightly invaded the rectal wall and the vagina.

hold true; these cysts are more common in women who have not borne children, nine to six in the fifteen married women; they are apparently rare in women who have had salpingitis, a common condition in women over 30 years of age and also a common cause of sterility.

In not a single instance of the twenty-three cases reported in this paper was there any gross evidence of a recent or an old inflammatory disease of tubal origin; the fimbriated extremities of the tubes in all cases appeared normal and whatever adhesions were present about the tubes were of extratubal origin, that is, from the contents of the cyst.

The age incidence is that of uterine myomas which we would expect to find present in a large percentage of the cases; and this is true. Uterine myomas of varying size and numbers were found in ten of the twenty-three cases. In eight of these they were small and insignificant; in the other two they were larger (Cases 8 and 22) and gave rise to the tumor or condition for which the operation was undertaken. Even in these two cases the myomas were of secondary importance to the

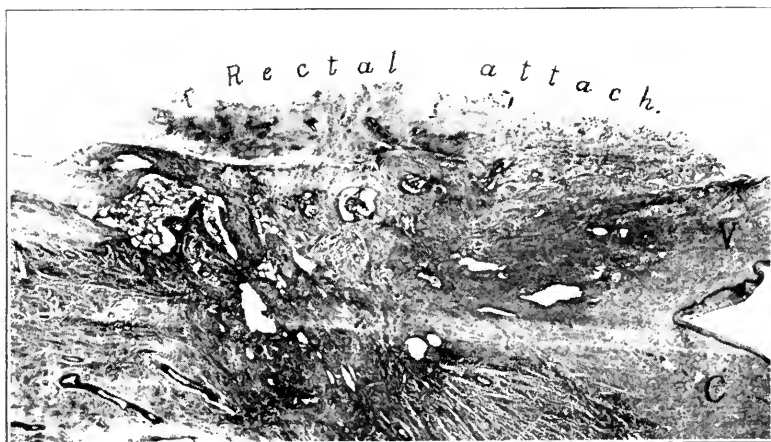


Fig. 35 (Case 13).—Stained longitudinal section of the posterior wall of the cervix ( $\times 5$ ) shown in Figure 34. The growth has extended about half way through the cervical wall and has only slightly invaded the rectum and vagina. Many varieties of adenoma and adenocystoma of endometrial type are present, as, areas resembling normal endometrium, glandular hypertrophy, small cysts with low, cuboidal, or columnar epithelium with, and without, a stroma between the epithelium and the underlying cervical tissue. No connection between the cervical mucosa and the adenoma was found.

adhesions resulting from the hemorrhagic cyst. Cancer of the uterine cervix was found once, and the condition resulting from the hemorrhagic cysts in this case was of minor importance (Case 20). Retroflexion or retroversion of the uterus was found in eleven instances, and in ten of these, adhesions between the uterus and the rectum were found. The condition under consideration must be looked on as a cause of adherent retroverted or retroflexed uterus, especially when the adhesions are situated between the rectum and the uterus.

The hemorrhagic cysts were usually small, from 2 to 4 cm. in diameter, only four were larger than 4 cm., the largest being approximately 9 cm., so the size rarely contributes to the subjective symptoms.

Also whether they are unilateral or bilateral probably has little bearing on these symptoms except as bilateral cysts may contribute to sterility. They were bilateral in eight of the twenty-three cases.

The situation and extent of the adhesions may or may not contribute to the subjective symptoms as in patients with adhesions due to other conditions. The menstrual history varied greatly. Painful menstruation was a symptom in eleven cases, while on the other hand, twelve of the patients menstruated without any pain. When one considers the many factors causing or contributing to dysmenorrhea,



Fig. 36 (Case 13).—Photomicrograph of a portion of the posterior wall of the cervix showing the invasion of the adenoma into the cervical tissues from the peritoneal surface of the cervix, i. e., from "without."

it is often difficult to determine the part played by any pathologic condition found in a single case. I believe adhesions due to these hemorrhagic cysts may cause painful menstruation, especially as in Cases 2, 4, and 22 in which the dysmenorrhea was of recent development and had increased in severity. The amount of the menstrual flow varied greatly in the cases in this series. It was moderate or scanty in fifteen, profuse in six and intermenstrual bleeding occurred



in two. In the six with profuse menstruation, intramural myomas were found in three; in two of which they were small, in two of the others a retroflexed uterus and hemorrhagic cyst were the only pathologic conditions present. In the sixth case, there was an extensive adenoma of the posterior uterine wall apparently not connected with the uterine mucosa. Of the two with intermenstrual bleeding, one had a cancer of the uterine cervix, in the other the pathologic conditions

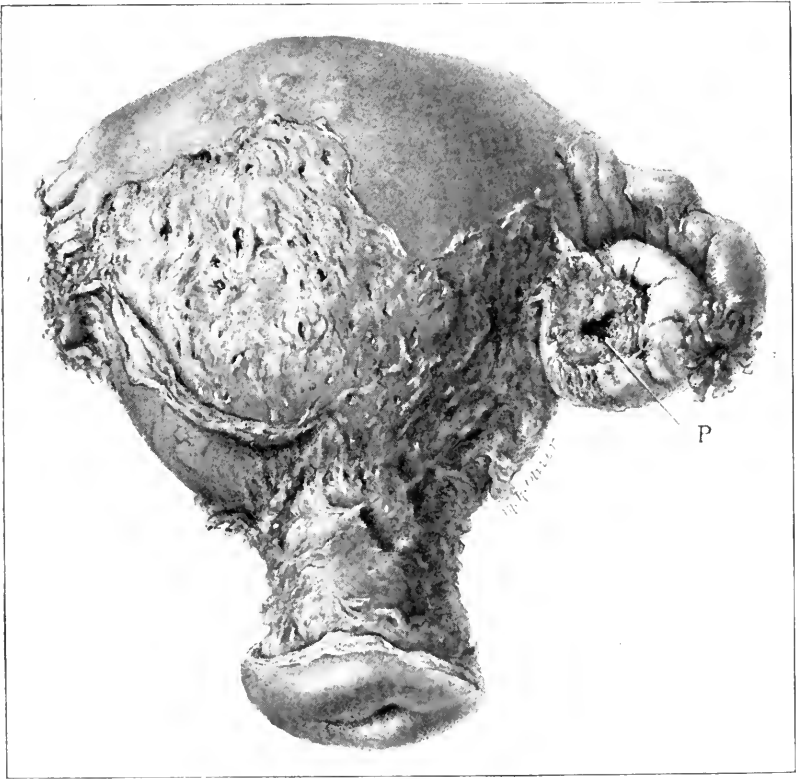


Fig. 37 (Case 15).—Perforating hemorrhagic cyst of the right ovary with diffuse superficial adenoma of endometrial type of the posterior uterine wall which had fused with the anterior wall of the rectum and the bottom of the culdesac. Posterior view of the uterus, right tube and ovary (natural size). The ovary had been freed at operation from the posterior surface of the uterus to which it was adherent. It is shown partially collapsed with a raw area and perforation in the center of it. The greater portion of the posterior wall of the uterus, represented by the large raw area, was adherent to the rectum and bottom of the culdesac. The small dark depressions and areas represent adenomatous tissue (blebs) (Fig. 41) which had been exposed or torn in freeing the uterus from the rectum and bottom of the culdesac and the ovary. The small elevations on the surface of the fundus above the large raw area represent superficial subperitoneal adenomatous blebs which had not been ruptured.

found were an adherent retroflexed uterus, bilateral ovarian hemorrhagic cysts and a small intramural myoma. It is very difficult to decide whether or not these cysts cause profuse or irregular (too frequent) menstruation.

Eight of the twenty-three patients did not have pain as a leading symptom. In three of these the adhesions were very extensive. Fifteen, however, did have pain. In three of these, the pain was probably due to trouble with the appendix. In the other twelve cases, the adhesions resulting from the ovarian cysts or cyst were the apparent cause of the pain. The pain varied in severity and location as does pain due to adhesions from any other cause. There is usually nothing characteristic about the pain present in this condition nor is there necessarily any relation between the extent of the adhesions and the severity of the pain. Only one patient gave a history of an acute onset with symptoms of peritonitis (Case 2). In all the others the onset was gradual. Four of the patients suffered greatly from constipation which amounted to partial obstruction in one instance (Case 19).

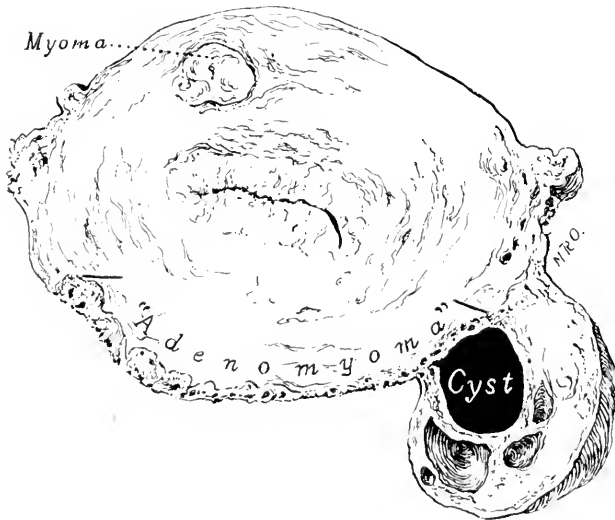


Fig. 38 (Case 15).—Cross section of the uterus with right ovary attached to the posterior uterine wall. The perforation in the ovary had been sealed by its attachment to the posterior wall of the uterus. The adenoma apparently beginning in the right ovarian cyst had extended across the entire posterior surface of the uterus at this level. There is a reaction of the uterine tissue about the glandular areas forming an "adenomyoma." Sections made through the entire uterine wall showed that the adenoma had invaded it only for the distance indicated in the illustration, and that none was found between this area and the uterine cavity.

Of the twenty-three patients, six presented symptoms due to other conditions and the hemorrhagic cysts were accidental findings. In seventeen of the twenty-three cases, the prominent symptom or symptoms were probably due to the cysts themselves or adhesions resulting from them. In twelve of the seventeen, pain was the one symptom from which the patient sought relief, in three increasing constipation, in one uterine bleeding and in one sterility.

#### SUMMARY OF CLINICAL FEATURES

The age at which such cysts with their sequelae occurs is usually between 30 years and the menopause.

There is often a history of sterility or of no children in several years. Sometimes there are not any subjective symptoms referable to this condition. If painful menstruation results, it is of the acquired variety, of recent development and may be progressive in severity.

If pain is present, it is not characteristic but varies in character as does pain associated with pelvic adhesions due to other conditions.

Sometimes constipation, worse at the menstrual period, is a suggestive symptom (Case 19). The symptoms of the advanced cases with narrowing of the lumen of the intestine are similar to those of intestinal obstruction due to other causes such as malignancy.

The physical signs vary greatly. If the cysts are small and adherent to the posterior surface of the uterus it may be difficult or impossible to detect them. If they are adherent to the posterior layer of the broad ligament or the side of the pelvis they are more readily palpated and

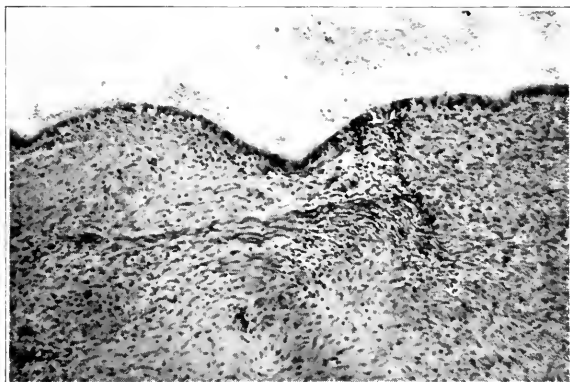


Fig. 39 (Case 15).—Photomicrograph of the wall of the hemorrhagic cyst shown in Figure 38. The entire cyst cavity is lined by a single layer of cuboidal or columnar cells with an underlying vascular stroma.

simulate adherent cystic ovaries or hydrosalpinx due to pelvic peritonitis of tubal origin. If the cysts are of medium size or larger and their adhesions are extensive the condition may simulate a malignant ovarian cyst (Case 9). The palpatory findings in the culdesac, when present, are the most characteristic physical signs. The uterus is often retroflexed or retroverted and adherent and the degree of adenomatous growth in the culdesac varies greatly in character in different cases. When slight, it is impossible to detect it. The involvement may be localized or diffuse. If localized, the area of induration may be flat or nodular, in the median line just behind the cervix or laterally in the region of the uterosacral ligaments. The induration is usually low down, but occasionally may be higher up. Sometimes it is best

detected on vaginal palpation and at other times felt best through the rectum. The diffuse and extensive involvement of the culdesac simulates the implantation of ovarian cancer or papilloma in this situation. The implantation from the latter source, however, is usually more extensive and much thicker.

The extensive involvement of the rectogenital space by "adenomyoma" is well described by Lockyer<sup>8</sup> in his excellent work on fibroids and allied tumors and by Cullen<sup>10</sup> in his published cases of "adenomyoma of the rectovaginal septum."

From this it can be seen that it is possible to make a tentative and often a probable diagnosis in a large percentage of the cases prior to operation. As we may diagnose a papillomatous or malignant ovarian cyst by palpating a cystic pelvic tumor which is usually

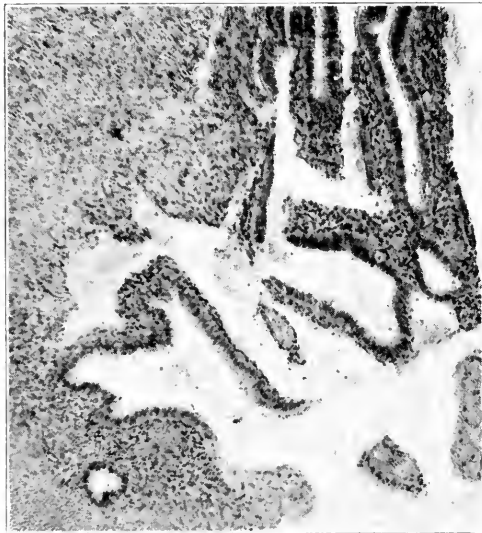


Fig. 40 (Case 15).—Photomicrograph of a cleft in the ovary near the site of perforation of the cyst. The cleft is lined by tissue of endometrial type resembling the normal endometrium more closely than that lining the cyst.

adherent and in addition find "involvement" of the culdesac due to the implantation of the growth in that situation, in like manner we are often able to diagnose this type of ovarian cyst with its secondary involvement of the culdesac. It differs from the malignant growth in that the ovarian tumor is usually much smaller, the culdesac involvement usually less and more localized, appearing as a nodule of localized thickening. The general clinical picture also is not that of malignancy.

#### TREATMENT

The operative treatment of any pelvic condition must be determined by many factors, such as the pathologic condition present, the age of

the patient, her desire for conservative surgery, the results of the operative treatment of similar conditions and especially the natural course of the disease when no operation was performed. There are obviously two pathologic conditions to treat, the one present in the ovary or ovaries, and the secondary adhesions in the pelvis which are often associated with an adenoma of endometrial type, the latter varying greatly in the degree to which it has invaded the tissues and organs involved.

One would suppose that with the establishment of the menopause ovarian function would cease and that then the tissues of endometrial type, wherever situated, would not only cease to grow but would actually atrophy. I believe this is the rule; undoubtedly, there may be

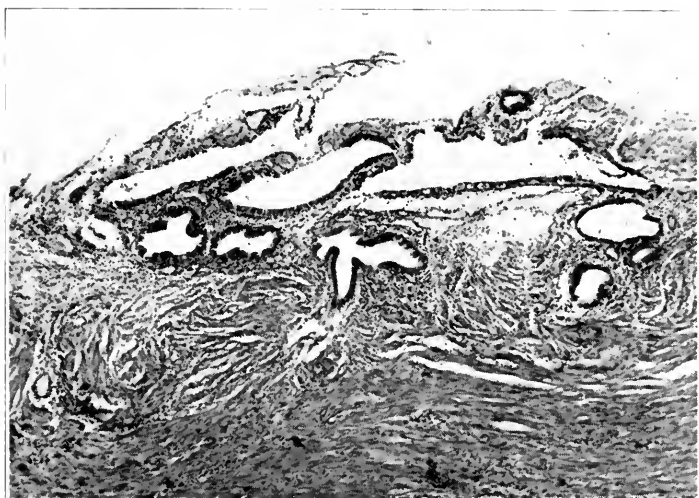


Fig. 41 (Case 15).—Photomicrograph of a section of the posterior uterine wall showing adenoma of endometrial type on its surface similar to that shown in Figure 24 (Case 21). As indicated, it is beginning to invade the uterine wall. The process in the ovarian hematoma, in the clefts of the ovary about the site of perforation, and the posterior surface of the uterus are the same, namely, an invasive adenoma of endometrial type. Apparently, the uterine involvement is secondary to the ovary by direct extension or implantation from the epithelial contents of the cyst.

an occasional exception. I have never found one of these cysts or a pelvic adenoma of endometrial type in a woman after the menopause.

To remove the pelvic adenoma and disregard the ovarian condition would be to leave the original growth behind, and furthermore, the persistence of the ovarian function might increase the growth of secondary pelvic adenomas not removed. *Certainly we would not sanction the surgical judgment of the operator who removed the secondary peritoneal implantations of ovarian papilloma or cancer and did not remove the primary ovarian tumor.* The conditions are analogous except that fortunately the adenoma of endometrial type

is only rarely sufficiently invasive to cause serious damage to the parts involved. By referring to the report of the cases in this article, one may see that various operations have been performed.

In some of the conservative operations, only the diseased portions of one or both ovaries have been removed (Cases 14 and 16). In others, one tube and ovary have been removed without excising the pelvic tissue in which adenoma was probably present (Cases 9, 10, 11 and 13). In still others, the entire uterus was removed, leaving behind one tube or ovary or a portion of an ovary and pelvic tissue was removed at the same time, which showed adenoma of endometrial type (Cases 15, 18 and 21). In the last group of cases, adenomatous tissue was undoubtedly left in the pelvis.



Fig. 42 (Case 15).—Sagittal section of the pelvis showing the relation of the "adenomyoma" to the uterus, rectum and vagina prior to the operation. The adenoma involves the superficial portion of the posterior uterine wall and has united it to the anterior wall of the rectum and posterior wall of the vagina. The upper part of the vagina has been pulled away from the rectum by the retroflexion. One can see how the adenoma would easily grow down between the rectum and vagina, invade the vaginal wall, and present in the vaginal vault behind the cervix, as in Figure 52 (Case 23).

In one of these conservative cases, a second operation has been necessary (Case 13); and in this instance, the adenoma in the culdesac had increased in size in less than a year's time and necessitated a radical operation. I believe that some of the other cases, in which I have employed conservative surgery, may later require secondary radical operations as Cases 10 and 11. Casler's<sup>9</sup> case already referred to is an extreme example of the possible result of conservative surgery in these cases. Only the end-result in a large number of cases of

conservative ovarian surgery will show whether or not it is justifiable. Even if it proves to be justifiable, I am sure that an occasional patient will require a secondary radical operation. It is possible that the rupture of the cyst at operation may "infect" the pelvic tissues with the epithelial contents of the cyst and that the retained ovary or ovaries may stimulate it to further growth.

I have never resorted to the extremely radical operations, as in cancer of the uterine cervix, and even in these operations it may be

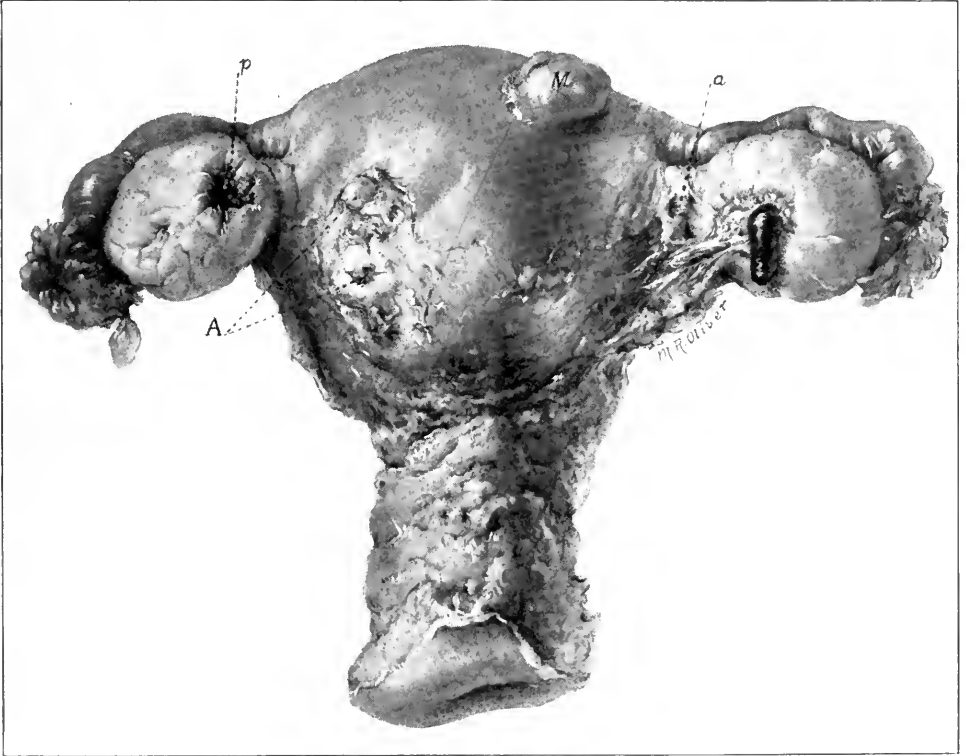


Fig. 43 (Case 17).—Perforating hemorrhagic cysts of both ovaries with discrete "adenomyomas" of the posterior wall of the uterus. Posterior view of the uterus, tubes and ovaries (natural size). At operation both ovaries were adherent to the posterior surface of the uterus. The left ovary is partially collapsed, due to the escape of the contents of the cyst; the raw area with perforation in the center is shown. The contents of the hematoma of the right ovary was thicker than that of the left and is indicated as oozing from the perforation. At and about the surface of the uterine wall which was adherent to the left ovary can be seen slight elevations (*A*) which proved to be superficial "adenomyomas" (Fig. 46). Adenoma of endometrial type was found developing between the adherent right ovarian ligament and the surface of the uterine wall at *a*, Figure 45. Sections were taken from other portions of the uterine wall and adenoma was not found.

impossible to remove all of the adenomatous growth. In the radical operations which I have employed, I have removed the entire uterus with both ovaries, and in freeing the uterus from the rectum, I have purposely kept close to the uterus, undoubtedly sometimes leaving adenoma in the rectal wall. In freeing the cervix laterally, I have

kept close to it, in one case intentionally leaving adenoma in the broad ligament because it was too extensive to remove (Case 12). Only the end-results of a large number of cases will show whether or not this type of radical operation is the one of choice. Undoubtedly, in any type of operation, no matter how radical, adenomas may sometimes be left in the pelvis, but with the removal of all ovarian tissue, I believe it will usually cease to grow and may atrophy (Cases 2, 3, 6 and 12).

In one instance (Case 19), I removed the entire uterus, both tubes and ovaries, a portion of the sigmoid; and in this case, adenoma was undoubtedly left in the anterior wall of the rectum and a distinct nodule in a portion of the sigmoid was not removed. I am anxiously awaiting the end-result in this case. So far she has been completely relieved and feels perfectly well.

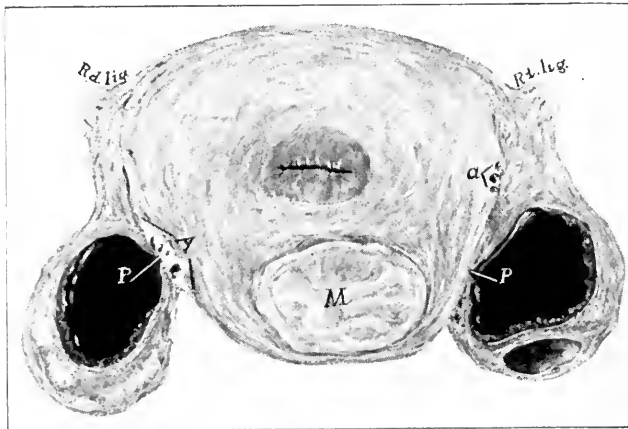


Fig. 44 (Case 17).—Cross section of the uterus and ovaries showing their relation prior to the operation (natural size). The ovaries are adherent to the posterior surface of the uterus at the site of perforation. The deeper portions of the ovarian cysts were lined by a wavy pigmented layer without an epithelial covering, while the proximal portions (toward the perforations) were lined by low, cuboidal and columnar epithelium, i. e., possibly a secondary "epithelialization" from the surface or periphery of the ovary about the site of perforation or regeneration of the epithelial lining of the cyst after hemorrhage, as in Figure 17. Adenomas of endometrial type were also present in the periphery of the ovary. Discrete superficial adenomyomas (*A*) are situated in the posterior uterine wall beneath the adherent left ovary at the site of perforation (Fig. 46), and adenoma of endometrial type is found developing between the right ovarian ligament and the uterine wall at *a* and invading the latter (Fig. 45).

There seems to be a great variation in the degree of "invasiveness" of the secondary pelvic deposits which is often evident in the individual case at operation. My present plan is to employ ovarian conservatism (excising the portion of the ovary or ovaries involved) or removing only the apparently diseased ovary in patients who desire to have the ovarian function maintained but only if the invasion of the pelvic tissues by the adenoma is slight. I am anxiously waiting to see



whether the end-results will justify this stand. I am inclined to believe that ovarian conservatism is a rather dangerous experiment. In all other cases, either when ovarian conservation is not strongly desired or when the pelvic growth is apparently actually invasive, I believe that all ovarian tissues should be removed and as much as possible of the pelvic growth with it. We must not lose sight of one fact, and that is that for many years we have been operating on these patients without realizing the exact nature of the disease. On the whole, the results have usually been quite satisfactory because the growth is usually only mildly invasive. With a better knowledge of this subject and by following up our cases, we should soon be able to determine the proper treatment of this condition

#### REPORT OF CASES

*CASE 1.—Perforating hemorrhagic cysts of both ovaries; multiple leiomyomas of the uterus; dense adhesions in the culdesac uniting the anterior rectal wall to the supravaginal portion of the cervix and the lower portion of the uterus. The induration of the anterior rectal wall was so great as to simulate malignancy.—Mrs. M. G., aged 46, complained of an abdominal tumor, of six*

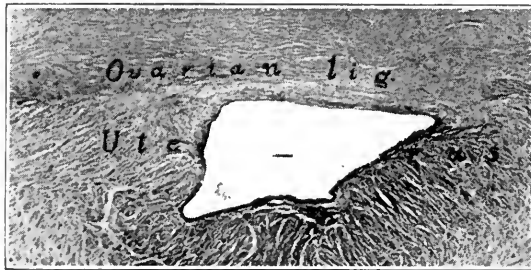


Fig. 45 (Case 17).—Photomicrograph of adenoma of endometrial type developing between the adherent right ovary and the uterus (Figs. 43 and 44). The adenoma can be seen sinking into the uterine wall.

months' duration, and constipation. She had never been pregnant; menstruation had been more profuse lately but regular and without pain. Pelvic examination revealed an adherent irregular "uterine" tumor, extending half way to the umbilicus. The preoperative diagnosis was a multinodular myomatous uterus, associated with pelvic adhesions, probably of tubal origin.

Operation at the Albany Hospital, March 5, 1910, demonstrated a multinodular myomatous uterus with adherent bilateral hemorrhagic ovarian cysts. Further details of this case have already been described in the text of the article in the section on incidence. The ovarian cysts and posterior wall of the uterus were not examined microscopically.

*CASE 2.—Perforating hemorrhagic cysts of both ovaries; "adenomyoma" of the posterior wall of the uterus, adherent to and invading the anterior wall of the rectum.—Miss B. K., aged 37, complained of profuse menstruation and indefinite pains in the lower abdomen. The menstruation was regular, profuse,*

more so lately, and accompanied with severe pain. Pelvic examination revealed the uterus to be slightly enlarged and apparently adherent, with "inflammatory masses" on each side. Preoperative diagnosis was a myomatous uterus (probably an intramural myoma) with chronic "inflammatory disease" of the tubes and ovaries.

At operation at the Albany Hospital, March 27, 1912, an enlarged uterus was found adherent to the rectum with adherent moderate sized ovarian cysts. On freeing the latter, "chocolate" fluid escaped. The uterus was freed from the rectum with great difficulty. The appendix, both tubes, ovaries and uterus were removed. The tubes appeared normal, both ovaries had been converted into cysts approximate 4 and 6 cm. in diameter. They were not examined microscopically. The posterior portion of the posterior wall of the uterus was occupied by an "adenomyoma" which apparently was not continuous with the mucosa of the uterine cavity. The "adenomyoma" had "extended through" the uterine wall posteriorly and apparently had actually invaded the anterior wall of the rectum (Fig. 64). In freeing the uterus from the rectum, some of the growth was probably left attached to, or in, the rectal wall. The patient made a satisfactory convalescence and has remained well even though it is doubtful whether all the adenomatous tissue was removed at operation.



Fig. 46 (Case 17).—Enlargement ( $\times 5$ ) of "adenomyoma" situated in the posterior wall of the uterus beneath the adherent left ovary (Figs. 43 and 44). Several sections were made of the posterior uterine wall and adenoma of endometrial type was found only in the portions of the uterine wall to which the ovaries were adherent, suggesting an intimate relation between the adenoma of endometrial type of the ovary and that developing in the uterine wall.

*CASE 3.—Perforating hemorrhagic cysts of both ovaries; adherent retroflexed uterus; adenoma of endometrial type invading the posterior wall of the uterus and uniting it with the anterior wall of the rectum.*—Mrs. C. A. D., aged 37, complained of pain of one year's duration in the left side of the lower part of the abdomen. She had been in bed ten days at the onset of the pain. The diagnosis of "peritonitis" was made at that time. She had been married eleven years, had two children, 10 and 8 years of age, and no miscarriages. The menstruation was regular, moderate and normal, the last flow being a week before the operation. Pelvic examination revealed the uterus to be retroflexed, adherent, with probable cystic inflammatory masses on each side. Preoperative diagnosis was an adherent retroflexed uterus with bilateral hydrosalpinx or adherent cystic ovaries.

At operation at the Albany Hospital, April 26, 1912, an adherent retroflexed uterus was found with adherent cystic ovaries. On freeing the latter, "chocolate"

fluid escaped. The uterus was freed from the rectum with difficulty. The appendix, both tubes and ovaries and the uterus were removed. The tubes appeared normal; each ovary contained a hematoma, the one in the left ovary being the larger (about 3 cm. in diameter). Histologically, the epithelial lining of the cysts was for the most part lacking. When present, it was low, cuboidal, resting on ovarian tissue without any intervening stroma. In a few places in the cyst wall, definite glandlike structures, lined by columnar cells similar to uterine glands, were found. The lower portion of the posterior wall of the uterus and the supravaginal portion of the cervix were invaded by an adenomatous growth of endometrial type. The depth of the invasion was not more than 4 or 5 mm. (Fig. 63). In places, there was a reaction of the tissues of the uterine wall forming a definite nodule, i. e., an "adenomyoma." The patient made a satisfactory convalescence and has remained well.



Fig. 47 (Case 23).—Perforating hemorrhagic cyst of the left ovary; adherent retroverted uterus; adenoma of endometrial type of the culdesac invading the posterior wall of the cervix and extending through the vagina and presenting as a hemorrhagic cyst in the vaginal vault. View of pelvic contents from sketch made at the operation (slightly reduced in size). The uterus was retroverted, the ovary drawn up over the left tube and adherent to the round ligament. The tip of the omentum was also adherent to the ovary and the round ligament at this point. The right tube and ovary were apparently normal. On freeing the omentum, "chocolate" fluid escaped from the perforated ovarian cyst, the perforation having been sealed by the omentum and round ligament.

CASE 4.—*Perforating hemorrhagic cyst of the left ovary; multinodular myomatous uterus; submucous "adenomyoma" of the right uterine cornu; dense adhesions in the culdesac uniting the posterior wall of the uterus to the rectum.*—Miss E. D. W., aged 40, complained of severe dysmenorrhea of four months' duration, especially in the left side, and some pain in the same side for a week after the menses had ceased. The menstruation was regular, moderate, free from pain until the last four months; since then there has been severe pain as noted above. Pelvic examination demonstrated the uterus to be irregularly enlarged and apparently adherent. Preoperative diagnosis was an adherent myomatous uterus.

Operation at the Albany Hospital, Oct. 11, 1917, revealed the uterus to be irregularly enlarged with an adherent ovarian cyst, approximately 6 cm. in diameter on the left side. On freeing the latter, "chocolate" fluid escaped. The uterus was adherent to the rectum. The appendix, both tubes, ovaries and the entire uterus were removed. The tubes appeared normal, the right ovary was cystic, the left was converted into a hemorrhagic cyst. There were multiple leiomyomas in the uterus and an "adenomyoma" in the right uterine cornu (Fig. 15). Sections of the left ovary were not satisfactory and none were made of the posterior uterine wall to determine whether or not adenomyoma of endometrial type was present. The patient made a satisfactory convalescence and has remained well.

CASE 5.—*Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus; tip of the appendix adherent to the cyst.*—Miss G. D., aged 28, complained of two "attacks of appendicitis," the first one three months ago and the last one a month ago. She was in bed about a week with each



Fig. 48 (Case 23).—Cross section of the ovary shown in Figure 47 (natural size). The ovarian hematoma is for the most part lined by a single layer of columnar cells with a vascular underlying stroma (Fig. 49). In places where the epithelium is absent, a thick layer filled with pigmented cells is present, evidence of a previous stromal hemorrhage. A corpus luteum (L) is situated near the ovarian hematoma as in Figure 16 (Case 21).

attack. The menstruation was apt to be two or three days late and slight in amount; there was slight pain and the last flow was a week before the operation. Pelvic examination showed the uterus to be retroflexed and adherent, with an adherent cystic mass in the right side of the pelvis. The preoperative diagnosis was adherent retroflexed uterus with adherent ovarian cyst.

Operation at the Albany Hospital, Feb. 7, 1918, revealed an adherent retroflexed uterus, with an adherent ovarian cyst on the right side. The appendix dipped into the pelvis and was adherent by its tip (Fig. 11). On freeing the cyst, "chocolate fluid" escaped. The appendix, right tube and ovary were removed and the uterus was suspended. Only one section from the ovarian cyst was made for microscopic diagnosis; this showed a cyst with its wall lined by low and cuboidal epithelium. No sections were taken from the posterior wall of the uterus to see whether or not adenoma of endometrial type was present.

CASE 6.—*Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus; "adenomyoma" of posterior uterine wall; gallstones.*—Mrs. J. A. J., aged 45, complained of indigestion and attacks of pain in the upper right abdomen. She had been jaundiced four weeks before. There were no definite symptoms referable to the pelvic condition. She was not constipated. She had had one child—13 years old. The menstruation was regular but scanty; there was no pain; the last flow was a week before the operation. The pelvic examination showed the uterus to be enlarged, retroflexed and adherent. The preoperative diagnosis was gallstones and an adherent myomatous uterus.

Operation was performed at the Albany Hospital June 13, 1918. A median incision was made and the gallbladder palpated and gallstones felt. The appendix was then removed. The uterus was enlarged, retroflexed, and densely adherent to the rectum. On freeing the right ovary "chocolate" fluid escaped. Both tubes and ovaries and the entire uterus were removed. An incision was then made over the gallbladder, and it was removed. Both tubes were normal,

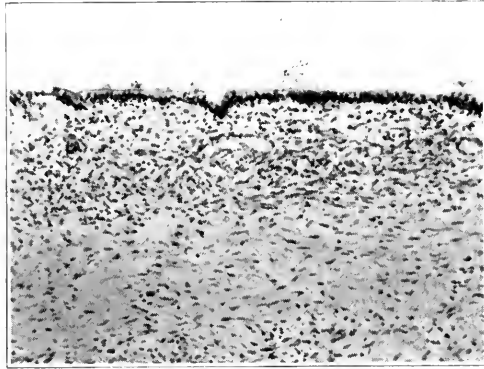


Fig. 49 (Case 23).—Photomicrograph of the wall of the cyst from the portion lined by columnar epithelium with an underlying vascular stroma similar to Figure 19 (Case 21), and Figure 39 (Case 15).

the left ovary was normal, the right ovary contained a hemorrhagic cyst about 2.5 cm. in diameter. There was a superficial "adenomyoma" of the posterior wall of the uterus which had "united" it to the anterior wall of the rectum. The exact depth of the invasion or the involvement of the uterus wall was not determined. The hemorrhagic cyst was lined by low, cuboidal and columnar epithelium, the columnar predominating. There was a vascular subepithelial stroma, containing evidence of old and recent hemorrhages and an occasional gland, which resembled a uterine gland. The patient made a satisfactory convalescence and has remained well.

CASE 7.—*Perforating hemorrhagic cysts of both ovaries; multiple ovarian hematomas; small leiomyomas of the uterus, adhesions between the posterior uterine wall and the ovaries.*—Mrs. X. W., aged 35, complained of uterine bleeding which had occurred six times in the last twelve weeks. She had never been pregnant; the menstruation was regular, moderate and normal until the last three months. Since then it had been more profuse and frequent and had been accompanied with pain. Pelvic examination showed the uterus to be

slightly enlarged, and apparently irregular in consistency, with inflammatory masses on either side. Preoperative diagnosis was a myomatous uterus with bilateral "chronic pelvic peritonitis."

Operation at the Albany Hospital, Nov. 10, 1918, revealed both ovaries to be cystic and adherent to the posterior surface of the uterus. Small myomas were present in the uterus. On freeing the ovaries, "chocolate" fluid escaped. The appendix, both tubes and ovaries and the entire uterus were removed. The tubes appeared normal, both ovaries contained multiple hematomas from 1 to 1.5 to 4 cm. in diameter. Histologically, the hematomas represented various stages in the life cycle of "luteal" hematomas. In one cyst, an adenoma of endometrial type was found. Sections were made from the portion of the posterior uterine wall which was adherent to the ovaries and adenoma of endometrial type was not found. The patient made a satisfactory convalescence and has remained well.

*CASE 8.—Perforating hemorrhagic cyst of the left ovary; multiple leiomyomas of the uterus; dense adhesions between the posterior uterine wall and*

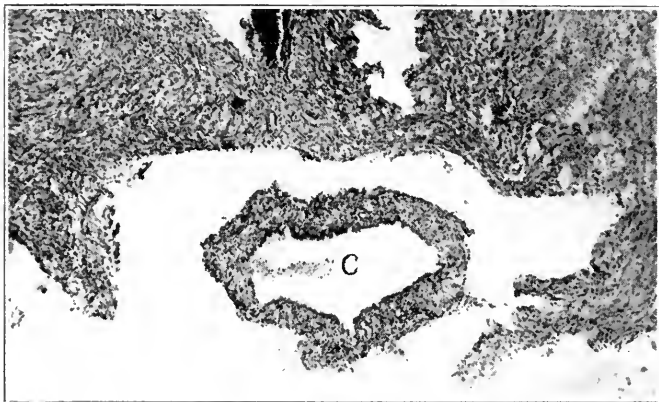


Fig. 50 (Case 23).—Photomicrograph of a small "cyst" partially detached from a pocket in the periphery of the ovary near the site of perforation (lower power than the preceding illustration). This cyst is lined by columnar cells surrounded by a cellular stroma and resembles the "cyst" on the surface of the round ligament (Fig. 70, Case 22). Both are apparently cysts of "endometrial" type.

*the rectum.*—Mrs. S. K., aged 46, complained of pain in the left side of the lower abdomen for ten years. She had never had any children but possibly had a miscarriage eighteen years ago. The menstruation was regular, without pain; but it had been very profuse for the last year, lasting from five to seven days. The last menstrual flow was two weeks before the operation. Pelvic examination showed the uterus to be irregularly enlarged and apparently fixed in the pelvis. Preoperative diagnosis was a myomatous uterus with pelvic adhesions.

Operation at the Albany Hospital, Jan. 16, 1919, revealed a multinodular myomatous uterus, pushed forward by a densely adherent left sided ovarian cyst about 8 cm. in diameter (Fig. 14). The right tube and ovary were normal. On freeing the ovarian cyst, a large amount of "chocolate" fluid escaped. The adhesions between the uterus and the rectum were very dense, and the two were separated with great difficulty. The appendix, both tubes, ovaries and

uterus were removed. Only one section was made from the cyst and that was unsatisfactory. Sections were not made from the posterior portion of the uterine wall to determine whether or not adenoma of endometrial type was present.

CASE 9.—*Perforating hemorrhagic cyst of both ovaries; dense adhesions in the culdesac uniting the anterior rectal wall to the supravaginal portion of the cervix and the lower portion of the uterus: postoperative hernia following the incision and drainage of appendiceal abscess twelve years previously.*—Mrs. C. J. H., aged 26, complained of pain in the right side. She had been married one and a half years and had not been pregnant. Menstruation was regular, normal, moderate in amount and not painful. The pain in the right side was of nine months' duration; at times it was severe enough to cause the patient to go to bed; she was not constipated. The pelvic examination showed the uterus to be of normal size and pushed forward by a "cystic" tumor extending nearly to the level of the umbilicus. The cyst appeared to be adherent. The preoperative diagnosis was an adherent ovarian cyst, probably a dermoid. On account of the adhesions, malignancy was also considered.

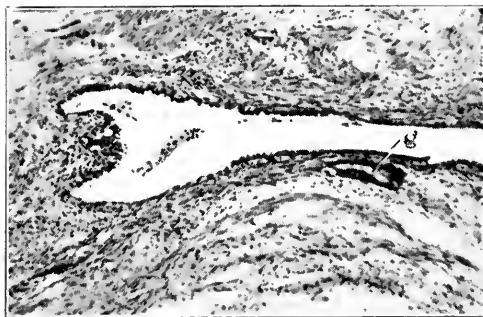


Fig. 51 (Case 23).—Photomicrograph of a peritoneal fold near the perforation of the cyst. This is an adenoma of endometrial type.

Operation at the Albany Hospital, March 17, 1920, revealed a left ovarian cyst about 9 cm. in diameter, posterior to the uterus and adherent to the posterior surface of the uterus and the anterior wall of the rectum (Figs. 12 and 13). On freeing it, a large amount of "chocolate" fluid escaped. A similar, but smaller, cyst was found in the right ovary. The appendix was removed; the hernia repaired; the left tube and ovary removed; the cyst excised from the right ovary and the uterus freed from the rectum and suspended. The tubes appeared normal. Histologically, the cysts were for the most part lined by epithelium of low to cuboidal type. Evidence of old and recent hemorrhages was found in the cyst wall. Tissue was not removed from the posterior wall of the uterus and the anterior wall of the rectum to determine whether or not adenomyoma of endometrial type was present. The patient made a satisfactory recovery and has remained well.

CASE 10.—*Perforating hemorrhagic cyst of the left ovary, adherent retroflexed uterus; acute appendicitis.*—Miss M. D., aged 34, was admitted to the Albany Hospital, May 8, 1920, with symptoms of acute appendicitis. Menstruation was regular, always profuse and accompanied by severe pain, especially in recent years; she often remained in bed for the first two days of the menstrual period. The last flow was two weeks before the operation. She

had had three "attacks of appendicitis" the first one in September, 1919, the second in December, 1919, and the third and present attack began the day before her admission to the hospital. The physical examination revealed tenderness and rigidity over the appendix; the uterus was retroflexed and adherent; the appendages on the left side were enlarged and adherent. The preoperative diagnosis was acute appendicitis, adherent retroflexed uterus, with adherent cystic ovary or hydrosalpinx on the left side.

Operation was performed on the day of admission. Through a median incision, the left ovary was found enlarged and adherent. On freeing the ovary, "chocolate" fluid escaped. The uterus was freed from the rectum, to which it was adherent, and suspended (Fig. 7). The appendix was also removed. Histologically the hemorrhagic cyst was lined by a single layer of low cuboidal or columnar epithelium, cuboidal predominating; there was in

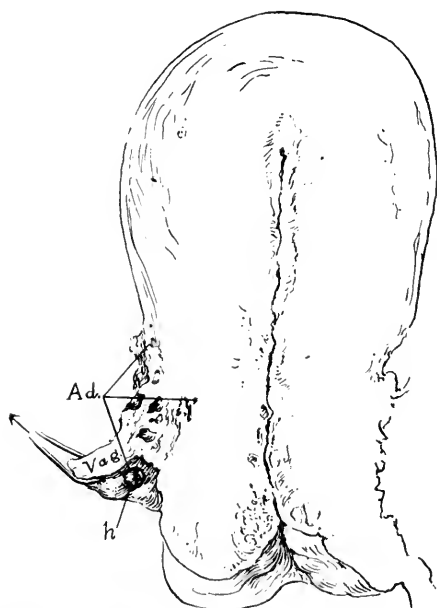


Fig. 52 (Case 23).—Sagittal section of the uterus;  $\times \frac{3}{4}$ . This shows the adenoma of endometrial type involving the posterior surface of the supravaginal portion of the cervix, invading the cervix and posterior vaginal wall at the cervicovaginal attachment and presenting in the posterior vault of the vagina as a small hemorrhagic cyst (*h*).

places a thin intervening vascular stroma between the epithelial lining and the ovarian tissue proper. Glandlike spaces lined by a single layer of columnar cells were found scattered through the cyst wall and were most numerous near the site of perforation (Fig. 9). A small "pocket" or cyst was situated lateral to the main cyst (Fig. 8). This pocket was lined by columnar epithelium accompanied by a definite underlying stroma, and in one place, there was a definite "endometrial" formation (Fig. 10). Evidence of old and recent hemorrhages were found in the cyst. Histologically, both cysts suggested that they were adenocystoma of the endometrial type. Tissues were not removed from the raw areas caused by freeing the adhesions to determine whether or not adenoma of endometrial type was situated in this area. The patient made a satisfactory surgical convalescence, but the dysmenorrhea has not been relieved



by the operation. I examined the patient in September, 1920, and could detect a definite small area of induration in the culdesac posterior to the cervix, which I believe is due to an adenoma of endometrial type in that situation.

CASE 11.—*Perforating hemorrhagic cyst of the right ovary, adherent to the side of the pelvis.*—Mrs. L. H., aged 30, complained of pain in the right side of the lower abdomen, especially during the menstrual period. The symptoms were of five months' duration. She had been married four years and had never been pregnant. Menstruation was regular, moderate in amount; she always had had some pain but this had been much worse for the last five months. The last flow was just passed. Pelvic examination showed the uterus to be normal in size and drawn slightly to the right side; the appendages on that side were apparently adherent. The preoperative diagnosis was "chronic pelvic inflammatory disease" probably of tubal origin.

Operation at the Albany Hospital, May 10, 1920, revealed the right ovary cystic and adherent to the side of the pelvis (Fig. 1). On freeing it, "chocolate" fluid escaped. The right tube, ovary and the appendix were removed. Histologically, the cyst for the most part lacked an epithelial lining, but when present, it consisted of a single layer of cells low to cuboidal in form (Fig. 3).

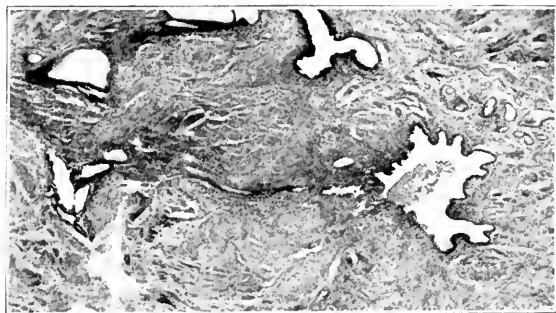


Fig. 53 (Case 23).—Photomicrograph of a portion of the cervix showing the "adenomyoma" with partially collapsed cavities which were filled with "menstrual" blood at the time of the operation.

In a few places, there was evidence of either old or recent hemorrhages in the wall of the cyst. Pockets or clefts were found in the ovary about the site of perforation. These pockets were lined by columnar cells with gland formation and a cellular stroma resembling endometrium (Fig. 4). The patient made a satisfactory recovery. I saw her June 16, 1921. She felt better than she did before the operation, but still had some pain in the lower abdomen. On examination, I found the left ovary to be enlarged and adherent to the side of the pelvis and a small area of induration in the culdesac. I believe that she now has a perforating hemorrhagic cyst of the left ovary with adenoma of endometrial type in the culdesac and may later require another operation.

CASE 12.—*Perforating hemorrhagic cysts of both ovaries, diffuse adenoma of endometrial type involving the posterior uterine wall, the anterior rectal wall and extending laterally into both broad ligaments.*—Mrs. T. H., aged 36, complained of increasing constipation of six months' duration but no pain or other discomfort. She had one child 6 years old. This was the only pregnancy. The menstruation was normal and moderate; there was no pain.

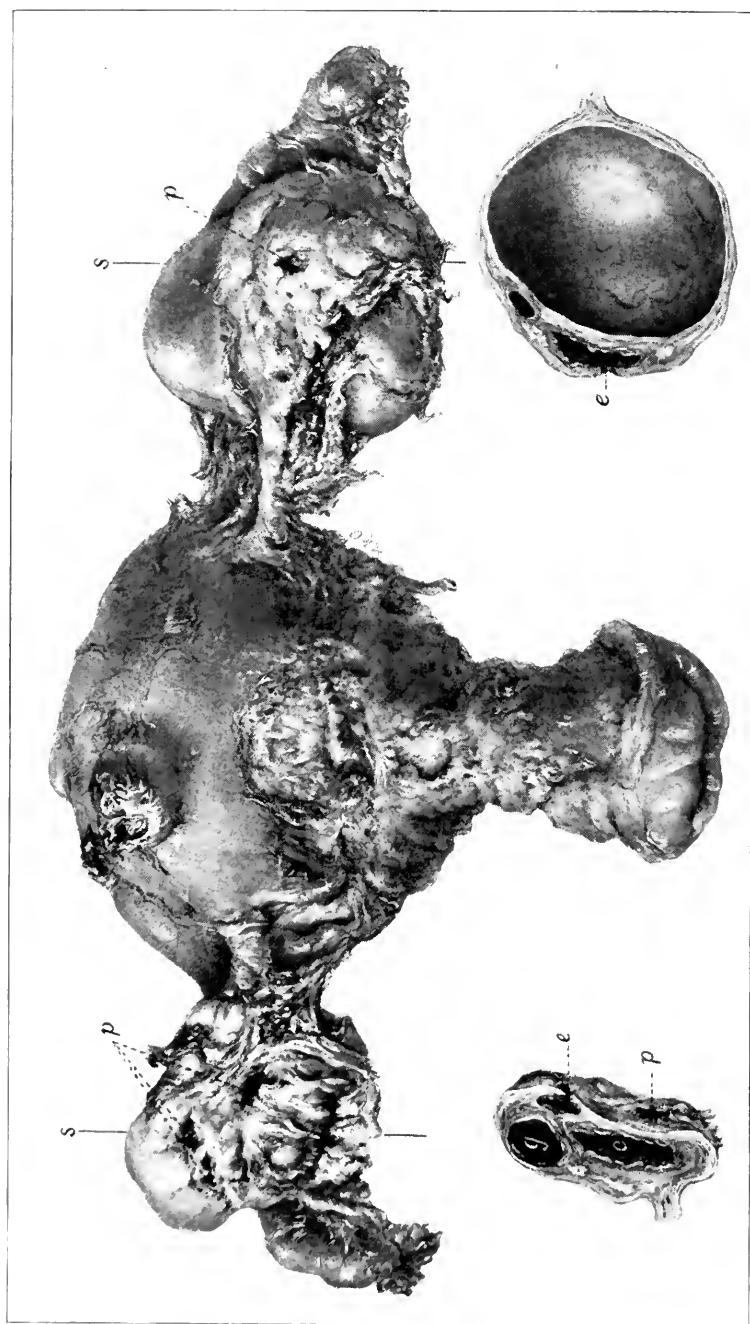


Fig. 54 (Case 19).—Perforating hemorrhagic cysts of both ovaries, adherent retroflexed uterus, small subserous leiomyoma, diffuse adenoma of endometrial type invading the posterior wall of the uterus and also probably the anterior wall of the rectum, adenoma of endometrial type of the sigmoid. Posterior view of the uterus, tubes and ovaries, the latter turned upward showing the perforation (*p*) on the lateral surface of the left ovary and the under surface of the right (natural size). Cross section of the left ovary shows *c*, the hematoma of "endometrial" type (Fig. 57), with perforation at *p*. The small pocket *e* is lined almost entirely with "endometrial" tissue (Fig. 58). The cyst *a* is a graafian follicle hematoma. The cross section of the right ovary shows a small hematoma *e* lined by "endometrial" tissue. The larger cavity is a graafian follicle cyst.

The last flow occurred four days before the operation. Pelvic examination showed the uterus to be slightly enlarged and fixed in the pelvis; there was induration in the culdesac, most marked high up, with distinct bulging into the rectum; this was best detected by rectal palpation. The preoperative diagnosis was dense pelvic adhesions (chronic pelvic peritonitis) with the possibility of implantation of cancer in the culdesac or cancer of the rectum at the junction of the rectum and the sigmoid.

At operation June 8, 1920, both ovaries were enlarged, cystic and adherent. On freeing them, "chocolate" fluid escaped. The uterus was fused to the rectum, with marked induration in both broad ligaments. The diagnosis was evident at the operation, that is, the adhesions and the induration of the broad ligaments were due to an adenoma of endometrial type. The appendix, both tubes and ovaries and the uterus were removed (Fig. 60). The uterus was freed from the rectum with great difficulty, and at the close of the operation,

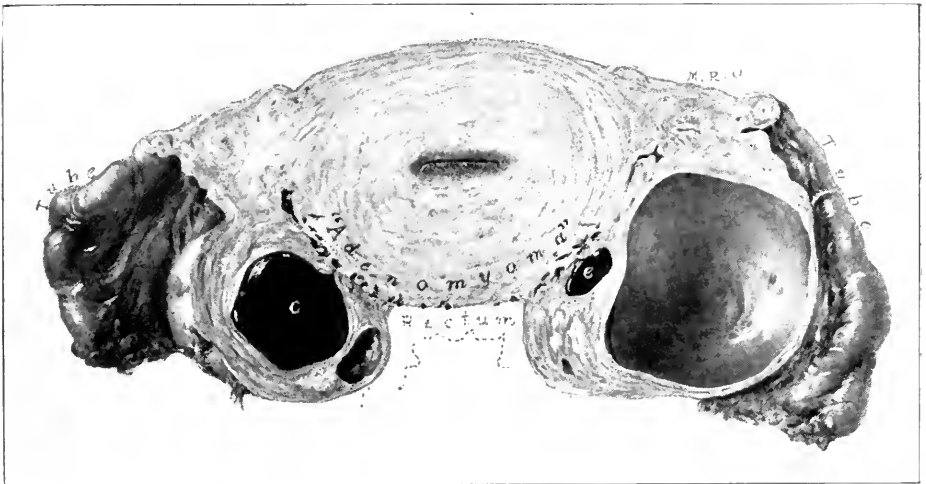


Fig. 55 (Case 19).—Cross section of the uterus and ovaries (natural size) indicating the condition found at operation. Both ovaries were adherent to the posterior surface of the uterus thus sealing the perforations. The adenoma had spread over the surface of the uterus and was just beginning to invade it (Fig. 59). The relation of the rectum to the uterus is indicated by the dotted lines. The larger hematoma, *c*, of the left ovary is shown in longitudinal section, and also the smaller one, *e*, of the right ovary, with the graafian follicle cyst lateral to it. Sections of the uterine wall failed to show any "endometrial" tissue between the superficial growth on its posterior surface and the mucosa of the uterine cavity.

the rectal wall still felt indurated especially over the area marked *x* in Figure 62. Undoubtedly, adenoma was left behind in the anterior wall of the rectum and in the broad ligament. Histologically the cyst of the right ovary was for the most part lacking in an epithelial lining, when present it was low or cuboidal. Columnar epithelium resembling that of the endometrium was found in clefts and pockets in the surface of the ovary about the site of perforation. Adenoma of endometrial type was found invading the posterior uterine wall and giving rise to a definite "adenomyoma" (Figs. 61 and 62). Sections between the "adenomyoma" and the uterine cavity did not show any connection between the two. The patient made a satisfactory recovery and has remained well. There has not been any evidence of an extension of the growth of the adenoma, undoubtedly left in the pelvis and in the anterior wall of the rectum. The patient was examined May 23, 1921. A slight area of induration, about the

size of the end of the examining finger, was palpated in the anterior wall of the rectum. The rectal mucosa was freely movable over it. This area of induration was definitely smaller than at the time of the operation.

CASE 13.—*Perforating hemorrhagic cyst of the right ovary; adenoma of endometrial type invading the posterior wall of the cervix, the vagina and the anterior wall of the rectum.*—Miss E. H., aged 30, complained of severe dysmenorrhea and marked constipation. The menstruation was regular, moderate in amount, always painful, but worse lately. The last flow occurred four weeks before the first operation and the patient was due to menstruate the day of the operation. Pelvic examination showed the uterus to be in normal position with a small definite localized area of induration just back of the cervix. The end of the examining finger just about covered the area which could be detected better on rectal palpation. To the right of this area and above could be felt an adherent cystic mass. The preoperative diagnosis was a



Fig. 56 (Case 19).—Enlargement ( $\times 5$ ) of the upper portion of the left ovary showing the collapsed hemorrhagic cyst *C* (Fig. 57), the endometrial pocket *E* (Fig. 58) and small fragments *M*, loosely attached to the surface of the ovary. These fragments contained "glands" of endometrial type, and should they become dislodged and escape into the peritoneal cavity might give rise to secondary growths of adenoma.

probable perforating hemorrhagic cyst of the right ovary with adhesions in the culdesac.

Operation at the Albany Hospital, June 28, 1920, revealed the left tube and ovary apparently normal. The right ovary was prolapsed and adherent to the side of the pelvis. The lower portion of the culdesac was obliterated by adhesions (Fig. 27). As the patient was very anxious for conservative surgery, I removed only the appendix, the right tube and ovary. Histologically the ovarian cyst was lined by a single layer of cuboidal to columnar epithelium with an underlying vascular stroma into which there was marked hemorrhage, i.e., "premenstrual" hematoma. Glandlike structures resembling uterine glands were present in the wall of the cyst near the site of perforation

(Fig. 29) and also on the surface of the ovary about this site (Fig. 32). Lateral to the cyst was a pocket lined by columnar cells of endometrial type with stroma and recent hemorrhage (Fig. 30). The patient made a satisfactory convalescence. Pelvic examination made before the patient left the hospital showed the same nodule posterior to the cervix, and I realized that it was probably due to adenoma of endometrial type. I saw her again in November, 1920. She had not improved, if anything the menstrual pain was worse. On examination, I found the pelvic condition about the same as before leaving the hospital except the nodule in the culdesac seemed a little larger. The patient was anxious to avoid another operation and decided to wait. She was seen again in March, 1921, and the history was the same as before. On examination, the induration in the culdesac seemed definitely larger.

A second operation was performed March 21, 1921, three weeks after the last menstrual period. On drawing the uterus forward, the anterior wall of the rectum was carried with it in a very characteristic manner (Fig. 33). The culdesac was obliterated to the level of the uterine origin of the uterosacral ligaments, the anterior wall of the rectum having become fused with the supra-



Fig 57 (Case 19).—Photomicrograph of a portion of the wall of the hematoma C. The cyst is lined in part by a single layer of epithelium, cuboidal and columnar (columnar epithelium is present in the center of the illustration). Recent hemorrhage is present in the subepithelial stroma, and to the right, the epithelial lining is lacking. The patient was operated on the "last" day of the menstrual period. Compare with Figure 29 (Case 13) when the patient was operated on the day that menstruation was due.

vaginal portion of the cervix up to this point. The rectum was freed from the posterior wall of the cervix, and the entire uterus and the remaining ovary were removed. The patient made a satisfactory convalescence. Histologically an adenoma of endometrial type was found invading the posterior wall of the cervix and to a lesser degree the vagina and the anterior wall of the rectum (Figs. 34, 35 and 36).

*CASE 14.—Perforating hemorrhagic cysts of both ovaries, adherent retroflexed uterus.*—Mrs. H. H., aged 31, complained of sterility. She had been married three years and had never been pregnant. The menstruation was occasionally irregular, extending over the usual period, from seven to ten days; it was always profuse; the last menstrual flow was two weeks before the operation. Pelvic examination showed the uterus to be retroflexed and adherent, as were also the appendages on both sides. There was a slight

degree of induration in the culdesac. The preoperative diagnosis was an adherent retroflexed uterus and possibly bilateral, perforating hemorrhagic cysts of the ovaries.

At operation at the Albany Hospital, July 6, 1920, the uterus was found to be retroflexed and adherent. Both ovaries were cystic and adherent; in freeing the latter, "chocolate" fluid escaped. The tubes appeared normal. The cysts were excised from the ovaries; the appendix removed and the uterus suspended and also curetted. Histologically the cysts were lined by a single layer of epithelium, low, cuboidal and columnar. In some places the epithelium rested directly on the ovarian tissue; in other places there was an intervening vascular cellular stroma; glandlike structures were also present and the histologic picture in some areas of the cyst wall resembled endometrial tissue. Subepithelial hematomas were also present. The patient made a satisfactory convalescence.



Fig. 58 (Case 19).—Photomicrograph showing the type of tissue lining the "pocket" of the left ovary. One would think it had been removed from the mucosa of the uterine cavity.

CASE 15.—*Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus, with a diffuse adenoma of endometrial type superficially involving the greater portion of the posterior wall of the uterus which was densely adherent to the bottom of the culdesac and rectum; intramural leiomyomas.*—Miss M. D., aged 39, complained of uterine bleeding and diarrhea of about six months' duration. The menstruation was regular until about six months before the operation. Since that time the patient had been flowing profusely, without any pain, every two weeks, and it often lasted a week. Diarrhea was of the same duration as the increased menstrual flow with watery bowel movements without pain or blood. Pelvic examination showed the uterus to be retroflexed, slightly enlarged, irregular and adherent. The appendages were not palpated on either side. The preoperative diagnosis was an adherent retroflexed myomatous uterus.

At operation at the Albany Hospital July 12, 1920, the uterus was found retroflexed and densely adherent to the rectum and the bottom of the culdesac (Fig. 42). The left tube and ovary were apparently normal. The right ovary was adherent to the posterior surface of the uterus (Fig. 38). On freeing it, "chocolate" fluid escaped. The appendix, right tube and ovary and the entire uterus were removed. Histologically the ovarian cyst was lined by a single layer of cuboidal to columnar epithelium resting in a cellular vascular stroma (Fig. 39). Recent hemorrhage was present in this stroma. In places, glandlike structures were present which resemble uterine glands. Epithelial tissue was found in the pockets in the surface of the ovary about the site of perforation, which even more closely resembled typical endometrium (Fig. 40). A diffuse adenoma of endometrial type (Fig. 37) had superficially invaded the greater portion of the posterior uterine wall, being present in the area of the uterine wall to which the ovary was adherent at the site of perforation and spreading over the entire area which was adherent to the bottom of the culdesac and the rectum and extending beneath the uterine serosa above this area, forming small blebs.

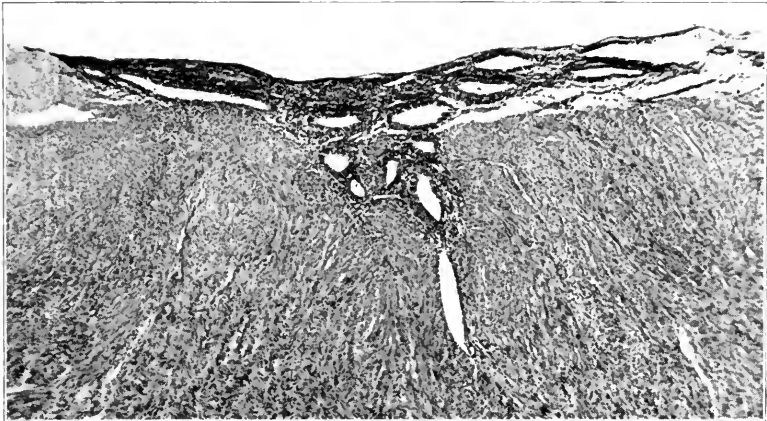


Fig. 59 (Case 19).—Photomicrograph (lower power) of a portion of the posterior wall of the uterus situated just beneath the adherent left ovary. The adenoma resembles a broad headed tack with a short point pushed into (invading) the uterine wall. The tissue lining, the hematoma *c*, the pocket *c* and that shown in this illustration all represent the same process as altered by physical conditions.

Histologically the lining of the hemorrhagic cyst, the tissues in the ovarian clefts about the site of perforation and the diffuse growth involving the posterior surface of the uterus were similar, except that in the ovary it was an adenocystoma of endometrial type with the cystoma feature predominating while in the uterus the adenomatous feature prevailed. The patient made a slow but satisfactory recovery, but died about six months later. The cause of death was not determined.

*CASE 16.—Perforating hemorrhagic cyst of the left ovary, retroflexed uterus; slight adhesions about the left ovary; chronic appendicitis.*—Mrs. J. W., aged 31, complained of pain in the right side in repeated attacks during the last ten years. She had one child, 5 years old, and possibly had a miscarriage one and one-half years ago. The menstruation was always profuse and painful. Pelvic examination showed the uterus to be retroflexed but freely movable. The preoperative diagnosis was chronic appendicitis and retroflexed uterus.



Fig. 60 (Case 12).—Perforating hemorrhagic cysts of both ovaries; adenoma of endometrial type of the posterior uterine wall uniting it to the rectum and extending laterally into both broad ligaments. Posterior view of the uterus, tubes and ovaries (natural size). The uterus was separated from the rectum with great difficulty and purposely some of the uterine tissue was left attached to the anterior wall of the rectum; hence the rough and ragged appearance of the uterus. The left ovary contains a graafian follicle cyst about 6 cm. in diameter with a smaller perforating hemorrhagic cyst on its lateral surface. The right ovary contains a collapsed hemorrhagic cyst perforating on its under surface. Histologically, the right cyst was the exact counterpart of the condition shown in Figures 3 and 4 (Case 11), namely, a hematoma of probable endometrial type in which recognizable "endometrial" tissue was found only in pockets in the periphery of the ovary about the perforation.



At operation at the Albany Hospital Oct. 28, 1920, the appendix which was adherent was removed. The uterus was retroflexed but freely movable. The left ovary was cystic and adherent. On freeing it, "chocolate" fluid escaped. The hematoma was excised from the left ovary, and the uterus suspended and curetted. Histologically, the cyst was lined by a single layer of cuboidal epithelium. Pockets of clefts were found in the ovary about the site of perforation which were lined by columnar epithelium with gland formation resembling endometrium. The patient made a satisfactory recovery and has remained well.

CASE 17.—*Perforating hemorrhagic cysts of both ovaries; adherent retroflexed uterus; multiple small leiomyomas; discrete superficial "adenomyomas" in the posterior uterine wall where the left ovary was adherent at the site of its perforation and adenoma beneath the adherent right ovary.*—Mrs. C. A. P.

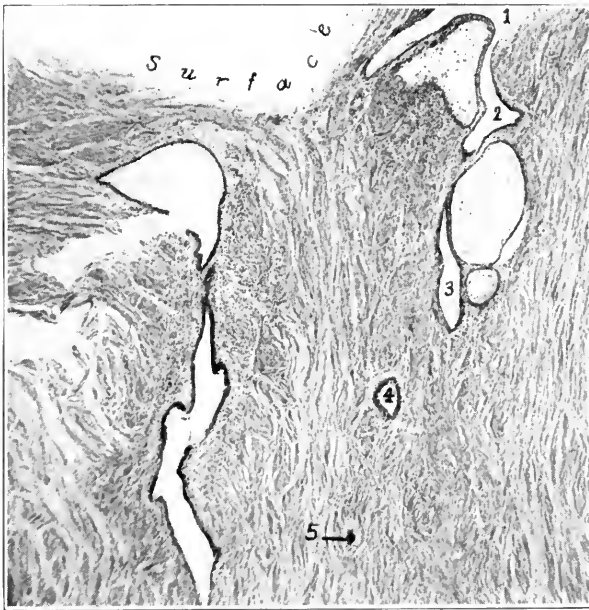


Fig. 61 (Case 12).—Photomicrograph of a portion of the posterior wall of the uterus beneath the attachment of the right ovary. The adenoma has invaded the uterus from the peritoneal surface like a long pointed crooked tack in which the head had probably been torn off during the operation. Compare with Figure 59 (Case 19).

aged 38, complained of uterine bleeding. She had been married eight years but had never been pregnant. The menstruation was regular, painless and always profuse, but more so lately. There had been irregular "spotting" for the last nine months. Pelvic examination showed the uterus to be retroverted, irregular in outline and apparently adherent. The appendages were not palpated. A slight area of induration could be palpated in the culdesac, apparently in the posterior wall of the uterus. It was detected best on rectal palpation. The preoperative diagnosis was an adherent retroverted uterus with small myomas.

At operation at the Albany Hospital Dec. 7, 1920, the uterus was found to be retroverted and adherent. Both ovaries were cystic and adherent to the posterior surface of the uterus. On freeing the ovaries, "chocolate" fluid

escaped. The appendix, both tubes and ovaries and the entire uterus were removed (Fig. 43). The tubes were normal. Histologically both hemorrhagic cysts contained a pigmented wavy "luteal" layer with evidence of "regeneration" of the epithelial lining of the cysts from the periphery of the ovary at the site of perforation. In the clefts in the ovary were areas of epithelial cells resembling endometrium. The area (Fig. 44) of the posterior uterine wall which was adherent to the left ovary showed a discrete nodule of "adenomyoma" (Fig. 46). Adenoma of endometrial type was found beneath the adherent right ovary (Figs. 44 and 45). The patient made a satisfactory convalescence and has remained well.

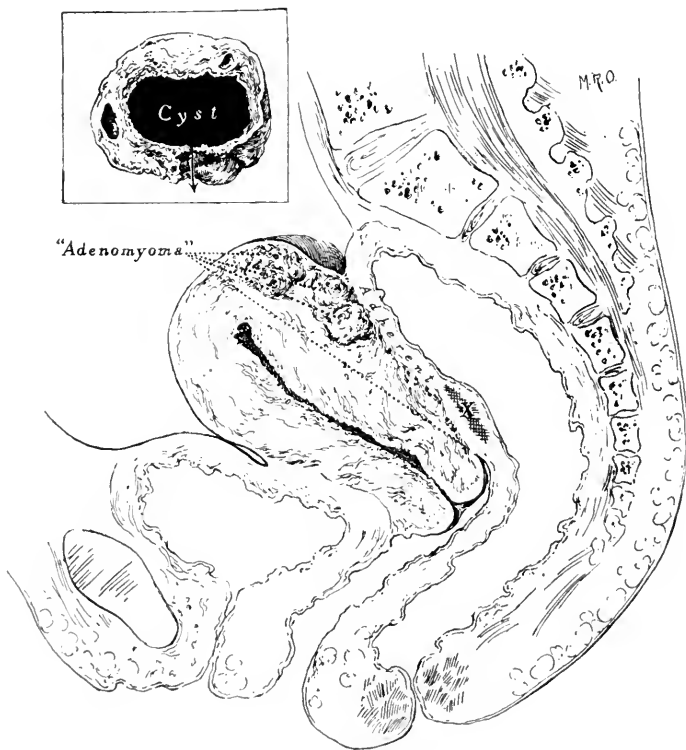


Fig. 62 (Case 12).—Sagittal section of the pelvis showing relation of the "adenomyomatous uterus" to the rectum prior to the operation;  $\times \frac{1}{2}$ . The adenoma arising in the culdesac "due to the escape of the contents of the cyst" has invaded the posterior wall of the uterus forming a definite "adenomyoma" of the fundus and uniting the uterus to the rectum and superficially invading that organ. The area marked *x* indicates a distinct nodule felt in the anterior rectal wall prior to, and also during, the operation. This nodule or thickening was not removed. The rectal mucosa over it was freely movable, and I believe it is a nodule of adenomatous tissue in the rectal wall. It is interesting to await its ultimate fate; so far it has not caused any trouble.

CASE 18.—*Perforating hemorrhagic cyst of the right ovary; multiple small leiomyomas of the uterus; adhesions between the uterus and the rectum with adenoma of endometrial type involving the posterior wall of the uterus and also the posterior surface of the right broad ligament.*—Mrs. H. K., aged 37, complained of marked constipation. She was married but had never been pregnant. The menstruation was regular, moderate and painless. Pelvic examination showed the uterus to be irregularly enlarged and adherent,

with an area of marked induration in the culdesac between the uterus and the rectum. This induration was very evident on rectal palpation and had led to a previous diagnosis of possible malignancy by another physician. The appendages on the left side were enlarged and cystic; those on the right were not palpated. The preoperative diagnosis was perforating hemorrhagic cyst of the left ovary with culdesac adhesions and adenoma of the endometrial type.

Operation at the Albany Hospital Dec. 8, 1920, revealed the uterus irregularly enlarged by multiple leiomyomas and the left ovary enlarged with multiple retentive cysts but freely movable. The right ovary was normal in size and adherent to the side of the pelvis. On freeing it, "chocolate" fluid escaped. The tubes appeared normal. The appendix, the left tube and ovary, the right tube, the greater portion of the right ovary and the entire uterus were removed. Microscopically, the cyst in the right ovary was lined by a single layer of epithelium of low and cuboidal type with a very vascular underlying stroma. In places the cyst wall suggested the remains of a "luteal" layer. Pockets or clefts were found in the ovary about the site of perforation. These pockets were lined by columnar epithelium with gland formation and a stroma resembling endometrium. Similar tissue was also found on the posterior surface of the right broad ligament. Not enough tissue from the uterus was examined to determine the extent of the adenoma involving its posterior surface. Only one section was made from this area; adenoma was found in this section but unfortunately the entire specimen was not saved for further sections. The patient made a satisfactory convalescence except for a slight infection of the lower end of the abdominal incision. The end-result of saving ovarian tissue in this case will be watched with interest.

CASE 19.—*Perforating hemorrhagic cysts of both ovaries; diffuse adenoma of endometrial type involving the posterior wall of the uterus, the anterior wall of the rectum, both broad ligaments and forming two separate nodules in the sigmoid ("adenomyoma" of the sigmoid).*—Mrs. J. W., aged 45, complained of marked constipation with attacks of obstruction beginning two years before the operation and gradually increased in severity. She had two children, the youngest 6 years old. The menstruation was regular, moderate and without pain until the last two years. During this time pain had been present, increasing in severity, and the flow had been decreasing in amount. The patient was operated on the last day of the flow. It is of great interest to note that the attacks of the most marked constipation occurred with the menstrual period. These had been especially bad during the last year. The pain was so severe the patient had to remain in bed; the abdomen often became distended, and sometimes there were nausea and vomiting. Bowel movements were obtained only with the greatest difficulty. No blood was ever observed in the evacuations. The abdomen remained tender for about a week after the cessation of the flow. Pelvic examination showed the uterus to be irregular, adherent and retroverted. The appendages were not palpated. Rectal palpation confirmed these findings. No localized induration was detected in the culdesac. Roentgenograms following a barium enema were made but no definite point of obstruction was found. The preoperative diagnosis was an adherent myomatous uterus with possibly a malignant growth of the sigmoid. The true condition was not considered.

At operation at the Albany Hospital Feb. 17, 1921, the uterus, containing small leiomyomas, was found retroverted and adherent to the rectum. A small amount of "old blood" was found free in the pelvis. Both ovaries were cystic

enlarged and adherent to the posterior surface of the uterus. On freeing the ovaries, "chocolate" fluid escaped. Two definite puckered areas were found in the sigmoid. One area was situated just above the apparent rectosigmoidal junction and the other about 8 cm. above this one. The upper area was not involved in or continuous with the adhesions uniting the uterus to the sigmoid or those between the ovaries and the uterus. On palpating each of these puckered areas, a definite nodule could be distinctly felt, apparently projecting into the lumen of the sigmoid. The upper one was the larger. The correct diagnosis was now apparent. The appendix was first removed, then both tubes and ovaries and the entire uterus (Figs. 54 and 55). The separation of the uterus from the rectum was extremely difficult for apparently the growth had invaded it and also the broad ligament on both sides. The upper and larger nodule in the sigmoid was excised and an end-to-end suture of the intestine made. Histologically the larger cyst of the left ovary was in part lined by a single layer of epithelium, the cuboidal type predominating, with evidence

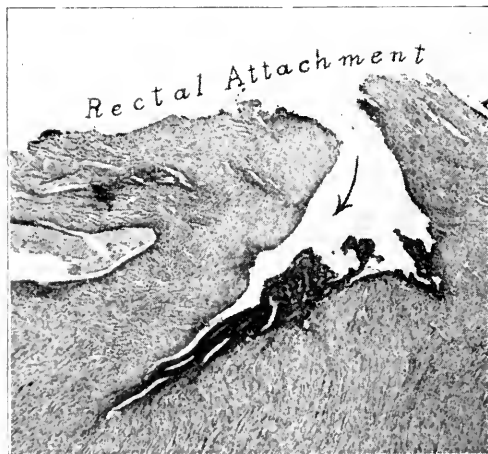


Fig. 63 (Case 3).—Photomicrograph of a section of the posterior wall of the uterus showing the ragged surface caused by freeing the uterus from its attachment to the rectum and also the apparent invasion of the uterine wall from its peritoneal surface (i. e., from "without") by adenoma of endometrial type. Perforating hemorrhagic cysts were present in both ovaries.

of recent hemorrhage into the underlying stroma (Fig. 57). Adenoma of endometrial type was found lining the smaller cyst or pocket (Fig. 58) and also on the surface of the ovary, between it and the uterus. The larger cyst of the right ovary was a graafian follicle cyst, but the smaller hemorrhagic cyst or pocket was lined by an adenoma of normal endometrial type; adenoma of endometrial type was found on the surface of the uterus superficially invading its posterior wall (Fig. 59). A similar adenoma was found invading the wall of the sigmoid on its peritoneal surface, extending through the entire wall into the submucosa. The patient made a satisfactory convalescence and has remained well. The end-result is awaited with great interest to determine the fate of the adenoma, undoubtedly still present in the sigmoid and the culdesac.

CASE 20.—*Perforating hemorrhagic cyst of the right ovary; multiple pelvic adenoma of endometrial type; cancer of the uterine cervix.*—Miss A. N., aged 41, complained of irregular uterine bleeding of three months' duration. The menstruation had been regular, moderate and painless. On account of the irregular uterine bleeding during the last three months, it was impossible to determine recent menstrual dates. There were no symptoms referable to the pelvic adenomas. Pelvic examination showed a friable everted growth occupying the vaginal portion of the cervix, especially the posterior lip. The uterus was freely movable, a definite nodule could be detected posterior to the cervix; this was more evident on the left side and best felt on rectal palpation. The preoperative diagnosis was everted type of cancer of the uterine cervix with possible extension posteriorly on the left side.

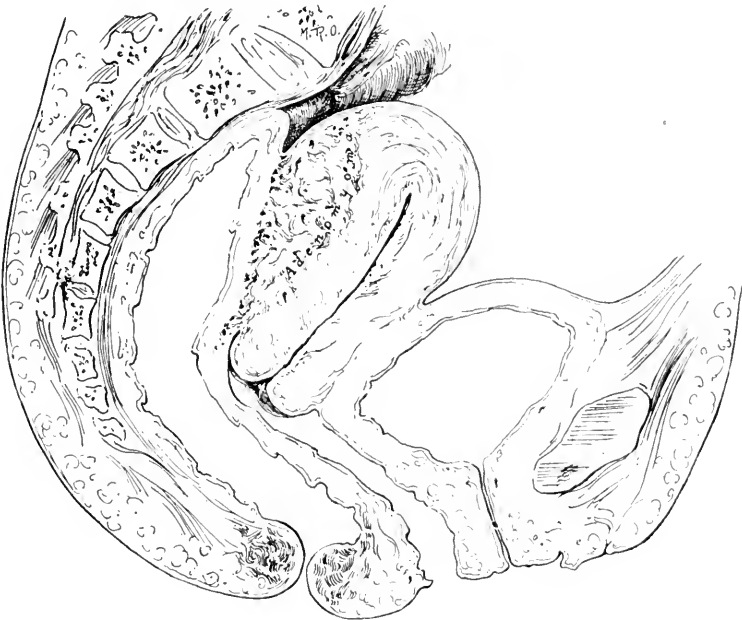


Fig. 64 (Case 2).—Perforating hemorrhagic cysts of both ovaries, diffuse "adenomyoma" of the posterior uterine wall which is fused with the anterior wall of the rectum. Sagittal section of the pelvis;  $\times \frac{1}{2}$ . The "adenomyoma" is apparently not connected with the mucosa of the uterine cavity. I believe this case represents an advanced stage of the conditions shown in the previous illustrations, namely, an "adenomyoma" of the uterus due to the invasion of the uterine wall by adenoma of endometrial type from the culdesac secondary to the escape of the contents of the hemorrhagic cysts into the pelvis.

At operation at the Albany Hospital March 1, 1921, the uterus was found to be freely movable, the right ovary was cystic and adherent to the posterior surface of the uterus. On freeing it, "chocolate" fluid escaped. The lower portion of the ureters and the bladder was freed, and the entire uterus was removed with a wide excision of the parametrium. The lymph nodes about the iliac vessels were also removed. Histologically, the cancer proved to be of the squamous cell variety; the lymph nodes removed did not show cancer. The right ovary contained a hematoma partly lined by the remains of a wavy pigmented layer and with an epithelial lining of the portion of the cyst wall

not occupied by the pigmented layer. Adenoma of endometrial type was also found in the periphery of the ovary about the site of perforation. Secondary adenoma of endometrial type was present in the culdesac just mesial to the left uterosacral ligament (Figs. 71, 72 and 74), in the surface of the posterior uterine wall where it was adherent to the ovary, and on the anterior surface of the uterus in the vesico-uterine fold of peritoneum, just beneath the left round ligament and also to the right of the median line (Fig. 73). The left ovary showed on its under surface a cleft lined by "endometrial" tissue. The patient made a satisfactory convalescence.

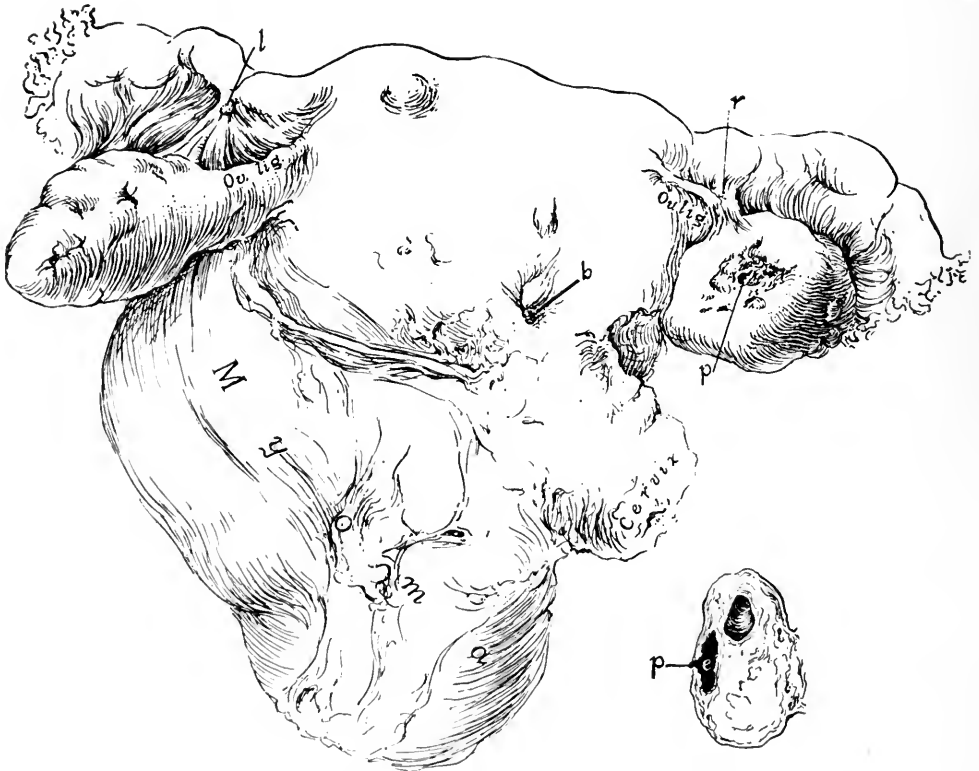


Fig. 65 (Case 22).—Perforating hemorrhagic cyst of the right ovary; multinodular myomatous uterus, deposits of adenoma (endometrial type) on the posterior and anterior surface of both broad ligaments and in the culdesac (the latter deposit not removed), multiple peritoneal blebs (adenomatous) on the anterior and posterior surfaces of the uterus and left broad ligament and in the vesico-uterine fold. Posterior surface of the uterus;  $\times \frac{3}{4}$ . The perforation *p* on the under surface of the right ovary is shown with raw area about it caused by freeing it from the posterior surface of the uterus to which it was adherent at *b*. The ovary is also shown in cross section. A hemorrhagic bleb with puckering of the tissue about it (excised for microscopic examination, but unfortunately lost) is indicated at *b*. A puckering of the right broad ligament between the tube and the ovarian ligament is shown—adenoma of endometrial type was found in this tissue (Fig. 67). A similar puckering is shown of the left broad ligament just beneath the tube, adenoma of endometrial type was also present here.

CASE 21.—Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus with diffuse adenoma of endometrial type involving the posterior surface of the uterus and the anterior wall of the rectum.—Mrs. T. E., aged 44, complained of marked constipation, much worse at the menstrual

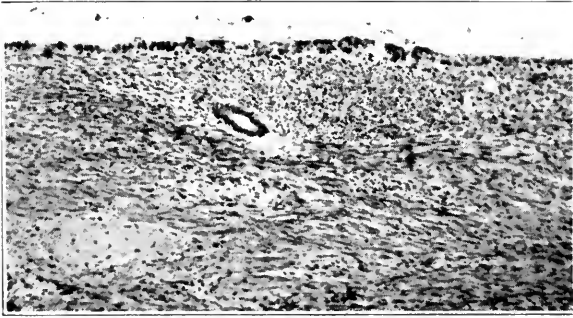


Fig. 66 (Case 22).—Photomicrograph of the wall of the ovarian hematoma showing that it is lined by a single layer of columnar cells with an underlying cellular stroma containing a "gland." It is a hematoma of "endometrial" type and the escape of its contents was the probable cause of the many adenomas of endometrial type found in the adhesions between the folds of peritoneum about the uterus and in the culdesac and also of some, and possibly all, of the peritoneal "blebs" on the surface of the uterus and its ligaments.

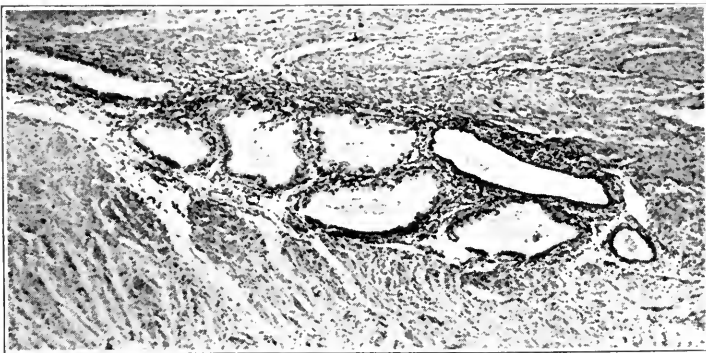


Fig. 67 (Case 22).—Photomicrograph of the puckerd right broad ligament shown in Figure 65. Adenoma of endometrial type has developed between the adherent folds of the ligament.

period, especially the last year. She also had indigestion. She had been married six years and had never been pregnant. Menstruation was regular, moderate in amount, occasionally accompanied with slight pain. The constipation was much worse at that time. The last flow occurred two weeks before the operation. Pelvic examination showed the uterus to be retroflexed and adherent, with a distinct area of induration back and above the cervix between the uterus and the rectum. The appendages were not palpated. Preoperative diagnosis was adherent retroflexed uterus, possible perforating hemorrhagic ovarian cyst with adenoma of the culdesac.

Operation was performed at the Albany Hospital March 21, 1921. A median incision was made; the gallbladder was palpated and a stone was felt. The uterus was retroflexed and adherent to the rectum. On drawing the uterus forward, the anterior rectal wall was carried with it. The right ovary was adherent to the side of the pelvis, directly over the course of the right ureter.

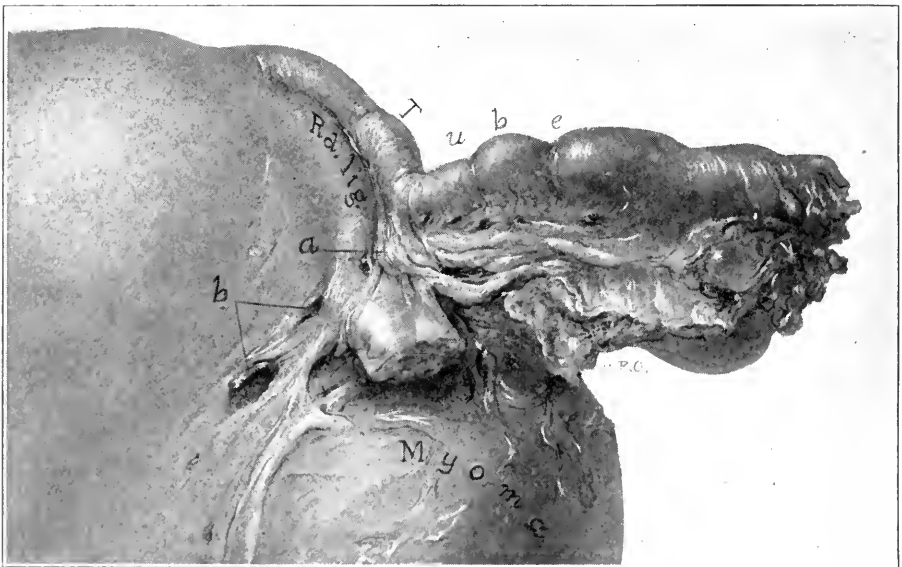


Fig. 68 (Case 22).—"Adenomyoma" of left round ligament with adhesions of the anterior layer of the broad ligament to it, multiple hemorrhagic peritoneal "blebs" (adenomatous). Anterior surface of the left uterine cornu, left tube and round ligament. The anterior surface of the broad ligament is puckered, drawn down and adherent to the round ligament (Fig. 69). The "blebs," many hemorrhagic, with puckering of the tissue about them are similar to the one shown in Figure 70.

On freeing the ovary, "chocolate" fluid escaped. The left ovary seemed normal. Both tubes appeared normal. The appendix, right tube and ovary and the entire uterus were removed (Fig. 16). The gallstone was removed and the gallbladder drained. The left tube and ovary were not removed because the patient was exceedingly nervous, and the ovary appeared normal. I am awaiting the end-results in this case with interest to see whether or not such ovarian conservatism is justifiable. I fully realized at the time that these cysts are often bilateral and that later she may have a similar condition in the left ovary with secondary growths in the pelvis, or the retention of the ovary may stimulate adenomatous deposits which may have been left in the pelvis



at the operation. Histologically the deeper portion of the ovarian cyst was lined by the remains of a pigmented "luteal" layer without an epithelial covering (Fig. 17). The portion of the cyst not occupied by the "luteal" layer was lined by a single layer of columnar epithelium with an underlying vascular stroma (Fig. 19). In the edges of the perforation and in the periphery of the ovary about the site of perforation were deposits of glandular tissue with cellular stroma closely resembling endometrium (Fig. 18). The histologic study of the entire ovary suggested that either the initial rupture of the cyst had been followed by its invasion by epithelium of endometrial type from the periphery of the ovary or else it represents the regeneration of the epithelial lining of an "endometrial" cyst after a hemorrhage. This epithelium extended through the perforation and was relining the cyst. At the same time the "luteal" layer was retrogressing (Fig. 20) and eventually the cyst might be converted into a cyst lined entirely by epithelium of the endometrial type. Adenoma of endometrial type was found in the tissue of the side of the pelvis which was adherent to the ovary at the site of rupture, also in a nodule in the vesico-



Fig. 69 (Case 22).—Photomicrograph of the left round ligament and the adherent broad ligament shown in Figure 68. Adenoma of endometrial type has developed in the peritoneal fold between the two ligaments 1, and has invaded the round ligament causing an "adenoma" of that structure.

uterine fold of peritoneum and over a large area of the posterior uterine wall (Figs. 21, 22, 23, 24 and 25) and the anterior wall of the rectum which were adherent to each other (Fig. 26). The patient made a satisfactory recovery.

CASE 22.—*Perforating hemorrhagic cyst of the right ovary; multiple leiomyomas of the uterus; multiple small adenomas of endometrial type on the posterior and the anterior surfaces of the broad ligaments.*—Mrs. A. D., aged 41, complained of pain in the left side, dysmenorrhea and constipation. She had had two children, 13 and 10 years of age. Menstruation was regular, moderate in amount and painless until three years ago. Pain had been present for three years, gradually increasing in severity so that she remained in bed for the first day of the flow. The last flow was three weeks before the operation. Pelvic examination showed an irregular, enlarged uterus with the largest nodule low in the pelvis and to the left side of the cervix. Movements of the uterus were restricted. Preoperative diagnosis was an adherent multinodular myomatous uterus.

Operation at the Albany Hospital April 7, 1921, under nitrous oxid and oxygen anesthesia (patient was a diabetic), revealed a multinodular, myomatous uterus, with the largest nodule about 9 cm. in its greatest diameter, extending between the layers of the left broad ligaments. The right ovary was found adherent to the posterior surface of the uterus, and in freeing it, a small amount of "chocolate" fluid escaped. A small nodule with puckering of the surrounding tissue was found on the posterior surface of both broad ligaments between the ovaries and the tube, a similar nodule was also present in the culdesac (not removed). A small hemorrhagic bleb, about 6 mm. in diameter with puckering of the tissues about it, was found on the part of the posterior surface of the uterus which had been adherent to the right ovary at its site of perforation. Similar blebs were found on the anterior surface of the left broad ligament and about the round ligament. The left broad ligament was puckered and adherent to the round ligament drawing the tube down toward it (Fig. 68). The tubes, ovaries, uterus and nearly the entire cervix were removed (appendix removed at a previous operation). Histologically, the cyst of the

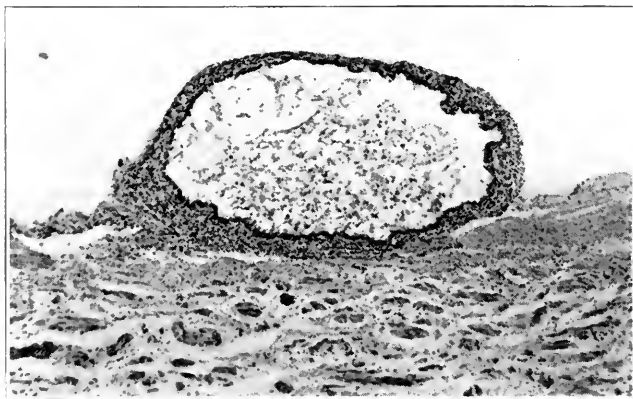


Fig. 70 (Case 22).—Photomicrograph (lower power than preceding) of one of the smaller peritoneal blebs or cysts shown in Figure 68. It is lined by columnar cells resting on a cellular stroma. Histologically, it is an "endometrial" cyst and similar to the cyst partially detached from the ovary shown in Figure 49 (Case 23). The other peritoneal cysts indicated in Figure 68 were examined microscopically and showed a similar condition. If these blebs are of endometrial type and are derived from the contents of the ovary, what is their development? Three possible explanations suggest themselves: first, from the deposit of epithelial cells from the ovary on the peritoneum and their subsequent development into a cyst as shown in Figure 22 (Case 21); second, a small cyst or dilated gland may have been detached from the ovary as shown in Figures 32 and 56 (*M*), and may be implanted on the peritoneum and then increase in size, and third, the "specific" irritation of the contents of the ovary caused a metaplasia of the peritoneal endothelium giving rise to a cyst of endometrial type.

right ovary was lined by columnar cells with a vascular stroma and in places gland formation. The histologic structure of this cyst was that of a cystoma of the endometrial type (Fig. 66). The nodules in the broad ligaments showed adenoma of endometrial type (Fig. 67), the one on the anterior surface of the left broad ligament had invaded the round ligament forming an "adenomyoma" (Fig. 69). The blebs were interesting in that they were lined by low, cuboidal and columnar epithelium with a vascular underlying stroma (Fig. 70). The supporters of the serosal origin of adenomyoma would probably interpret them as the development of adenomyoma from metaplasia of the peritoneal "endo-

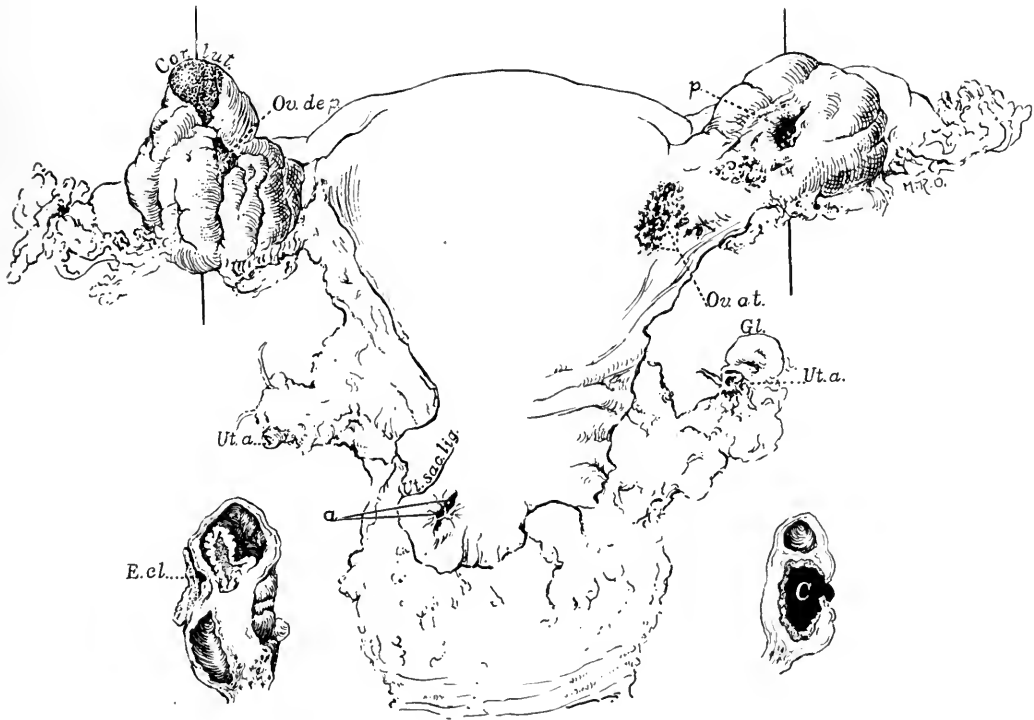


Fig. 71 (Case 20).—Perforating hemorrhagic cyst of the right ovary; adenoma of endometrial type near the left uterosacral ligament below the left round ligament and in the vesico-uterine fold; cancer of the uterine cervix. Posterior surface of the uterus, tubes and ovaries;  $\times \frac{2}{3}$ . The right ovary was adherent to the posterior surface of the uterus at *Or.* Its perforation (*p*) is situated on the lateral surface. On the lateral surface of the left ovary is a small pigmented area *ov. dep.* beneath which is a space lined by columnar epithelium. *Gl.* represents a parametrial lymph node. Just mesial to the left uterosacral ligament is an indurated area with puckering of the peritoneum about it. Small pigmented cysts can be seen in this tissue (Figs. 72 and 74). Histologically, portions of the right ovarian hematoma, the epithelial cleft in the left ovary and the nodules near the left uterosacral ligament, left round ligament and in the vesico-uterine fold are similar, namely, adenocystomas of endometrial type, apparently primary in the ovaries with secondary deposits in the other places.

thelium." For further description of the findings in this case see the illustrations with their legends. The patient made a satisfactory recovery.

CASE 23.—*Perforating hemorrhagic cyst of the left ovary; adherent retroflexed uterus with adenoma of endometrial type involving the posterior surface of the cervix, uniting the latter to the bottom of the culdesac and the rectum and extending through the vaginal wall and presenting as a hemorrhagic cyst in the vaginal vault behind the cervix.*—Mrs. G. H., aged 47, complained of bearing down sensations. She had had four children, the youngest 10 years of age. Menstruation was regular, moderate in amount and painless. The last flow occurred two weeks before the operation. She was not constipated. Pelvic examination showed a weakened pelvic floor, uterus retroflexed and adherent, with a small nodule in the posterior vaginal vault just back of the cervix, and to the left of the median line. A definite nodular induration was felt in the bottom of the culdesac between the cervix and the rectum. The appendages on the right side felt normal, while the left appendages seemed enlarged and adherent. The preoperative diagnosis was an adherent retroflexed uterus, perforating hemorrhagic cyst of the left ovary and adenoma of endometrial type in the bottom of the culdesac and extending through the vaginal vault.



Fig. 72 (Case 20).—Indurated area mesial to left uterosacral ligament containing small cysts (Fig. 73). Note the puckering of the peritoneum about this area, see Figure 74. (I have not yet been able to demonstrate the development of this type of lesion as I have that shown in Figure 24.)

At operation at the Albany Hospital April 18, 1921, the uterus was found to be retroflexed and adherent. The omentum was adherent to the left ovary and the left round ligament. The left ovary was cystic, drawn up over the left tube and adherent at the point of rupture to the left round ligament and omentum (Fig. 47). The right tube and ovary were freely movable. On drawing the uterus forward, the anterior wall of the rectum, which was adherent to the supravaginal portion of the cervix, was carried with it in a characteristic manner. On freeing the omentum and left ovary, "chocolate" fluid escaped (Fig. 48). The appendix, both tubes and ovaries and the entire uterus were removed, and the pelvic floor was repaired. Histologically, the ovarian cyst was in part lined by cuboidal and columnar epithelium, columnar predominating with a vascular underlying stroma (Fig. 49) and evidence of old and recent hemorrhages. In other places, there was a wavy membrane filled with pigmented cells lining the cavity and without an epithelial covering, the probable results of hemorrhage into the wall of the cyst. Sections through the posterior wall of the cervix

and the vagina showed that these structures were invaded by an adenoma of endometrial type (Fig. 53), which at the time of operation was found filled with old blood forming small cavities. Adenoma of the endometrial type was also found in a fold of the peritoneum about the left round ligament where the perforating cyst had been sealed (Fig. 51). Histologically, the process in the ovary, the fold of the peritoneum about the round ligament, the posterior wall of the supravaginal portion of the cervix and the posterior vaginal wall are the same, namely, an adenoma of endometrial type. The patient made a satisfactory recovery.

#### CONCLUSIONS

Perforating hemorrhagic cysts of the ovary occur most frequently in women between 30 years of age and the menopause. In the twenty-three cases reported in this paper, only two were under 30 and the oldest patient was 47. It is quite a common condition, probably occurring in nearly 10 per cent. of the women of these age limits who require abdominal operations for the relief of pelvic disease. During the year, May 1, 1920, to May 1, 1921, I found perforating hemorrhagic cysts of the ovary in fourteen of 178 patients between 30 and 50 years of age who had an abdominal operation for some disease of the pelvic organs.

The cysts are usually small, between 2 and 4 cm. in diameter, occasionally less than 2 and also occasionally larger than 4 cm. They are quite frequently bilateral, as in eight of the twenty-three cases.

At operation the cyst or ovary is found to be adherent, and in freeing it the "chocolate" contents escape because a previous perforation, which had been sealed by whatever structure the ovary had become adherent to, is reopened or the cyst is torn. Adhesions, due to the "irritating" action of the material which had previously escaped from the ovary, are always present, and these vary greatly in location, density and extent. They may be found in any of the natural pockets and folds of the pelvis where such material would be apt to lodge, and especially in the culdesac. When slight, they simulate the adhesions resulting from pelvic peritonitis of tubal origin; on the other hand, the adhesions in the culdesac may be accompanied by such a marked reaction as to resemble malignancy.

The histologic findings in these cysts vary in different specimens and in different portions of the same cyst. With my present knowledge of their life history, I prefer to state "possibilities" rather than make definite statements which may later prove to be incorrect. There may be several varieties of these cysts; but I am more inclined to believe that most of the apparently different kinds represent various stages in the development and retrogression of one type of cyst and the various phases in its "menstrual" cycle. The initial perforation may have



Fig. 73 (Case 20).—Adenoma of endometrial type in the vesico-uterine fold just below the left round ligament. Sagittal section of the uterus;  $\times \frac{2}{3}$ . *A* indicates the situation of a small pigmented nodule with puckering of the peritoneum about it. A similar nodule was present in the vesico-uterine fold to the right of the midline corresponding to *X* in the illustration. Histologically, these nodules were similar to the one near the left uterosacral ligament (Fig. 74).



Fig. 74 (Case 20).—Enlargement ( $\times 10$ ) of a stained section of the indurated area mesial to the left uterosacral ligament (Figs. 71 and 72). Cystlike cavities are present which are lined by tissue of endometrial type and with evidence of former hemorrhage as shown by pigmented cells in their walls.

been the rupture of an "endometrial," graafian follicle or atretic follicle hematoma; or following ovulation, an abnormal corpus luteum may have developed due to the invasion of "endometrial tissue" present at the site of rupture. One group of these perforating hemorrhagic cysts shows these conditions: A portion of the hematoma, usually the deeper, is lined by a "luteal" membrane the exact origin of which in some specimens is difficult to state. The rest of the cyst, usually toward the perforation, is apparently being relined by the invasion of epithelium, through the perforation, from epithelium situated in the periphery of the ovary at the site of rupture. This epithelial relining or regeneration is of endometrial type, both in structure and in function. With the advance of the epithelial invasion, the "luteal" membrane retrogresses, and eventually the entire cyst may be relined by this epithelial tissue. This group represents either the development of an "endometrial" cyst from the invasion of a follicular hematoma by misplaced "endometrial" epithelium or else it represents the regeneration of an "endometrial" cyst after a hemorrhage ("menstrual"). Another group apparently represents either an earlier or a later stage of the former. The cysts in this group are entirely lined with epithelium, low, cuboidal or columnar; all three types of epithelium are often present in the same cyst. Usually there is a vascular cellular stroma not unlike that of the endometrium, between the epithelium and the ovarian tissue, often with evidence of old and recent hemorrhage. This stroma varies greatly in thickness and in some instances may be very thin or lacking. Structures, like uterine glands, may be present in this stroma, and these are usually most numerous near the site of the perforation. The entire cyst is like the epithelial portion of the cysts described in the first group, and all gradations between the two groups may be found.

The exact counterpart of the epithelial lining of these ovarian hematomas may be found in the uterine hematomas often occurring in "adenomyoma" of the uterus and apparently due to the retention of menstrual blood. Tissue of endometrial type is also present in pockets in the periphery of the ovary about the perforation, and the tissue in these pockets may resemble normal endometrium more closely than that lining the hematoma in the same ovary. The histologic study of these hematomas shows that periodic hemorrhage similar to that of menstruation occurs. I have come to the conclusion that these ovarian hematomas are of endometrial type just as are the uterine hematomas found in "adenomyoma" of the uterus.

I have never found these cysts in women after the menopause and some of those which I have studied were small and apparently retrogressing rapidly. In two instances in which I found adhesions with adenoma of endometrial type in the pelvis, but no gross evidence of

these cysts in the ovaries, pockets were found in the periphery of the ovaries lined by columnar cells and a cellular stroma resembling endometrial tissue. I interpreted these pockets as the possible remains of a perforating hemorrhagic cyst in which nearly complete retrogression had occurred. For these reasons I have concluded that their life may sometimes be of short duration, and the "characteristic" adhesions resulting from them may persist long after the cyst has disappeared.

The adhesions form equally as interesting a pathologic study as the cysts themselves because adenoma of endometrial type is present in the tissues involved by the adhesions in a large percentage of the cases. I have studied histologically the tissues involved by the adhesions outside the ovary in fourteen of the twenty-three specimens, and adenoma of endometrial type was found in thirteen of these.

Some time, or possibly many times, in the life of these hematomas, material, including epithelial tissue and blood ("menstrual"), may escape into the peritoneal cavity from the hemorrhagic cyst or from the "endometrial" pockets in the ovary about the site of perforation and, lodging in the natural pockets and peritoneal folds of the pelvis, they may cause adhesions. Adenoma of endometrial type often develops between the adherent folds of peritoneum thus resulting. *These adenomas may be small, and quiescent or they may be invasive. If invasive they may cause "adenomyoma" of the uterus by invasion of the uterine wall from "without" or "adenomyoma" of the uterosacral ligament, round ligament, rectovaginal septum, rectum, sigmoid, etc., namely, whatever structure or organ is invaded by the adenoma arising from the "infective" contents of the cyst or ovary lodging on its surface.* The question naturally arises, In what way do the contents of the cyst or ovary cause the development of these adenomas? Is it due to some "specific" irritant present in the cyst contents which stimulates the peritoneal "endothelium"; thus causing a metaplasia and the development of "endometrial" tissue typical both in structure and in function? Some may assert that dormant "endometrial" epithelium may be present in the tissues soiled by the contents of the cyst and this is stimulated to further growth. *It seems to me that the condition found in many of these specimens is analogous to the implantation of ovarian papilloma or cancer on the peritoneal surface of the pelvis from the rupture of an ovarian tumor containing these growths.*

I offer the following data as evidence that perforating hemorrhagic cysts of the ovary are hematomas of endometrial type.

1. These hematomas, as the uterine mucosa, manifest their "activity" during the menstrual life of the patient.

2. Histologically, the epithelial lining of the ovarian hematomas is similar to that of the uterine hematomas, due to the retention of "menstrual" blood, often present in "adenomyoma" of the uterus.



3. Periodic hemorrhages occur in the ovarian hematomas which are similar in gross and histologic appearance to that of menstruating endometrium.

4. The "chocolate" contents of the ovarian hematomas resemble old menstrual blood.

5. In two patients operated on at the time of the menstrual period, one the day that menstruation was due (Case 13, Fig. 29), and the other the last day of menstruation (Case 19, Fig. 57), the histologic changes in the ovarian "endometrial" tissue corresponded to the phase of the menstrual cycle indicated by the menstrual history of the patient.

6. The fact that material escaping from the ovarian hematomas may give rise to the development of adenoma of endometrial type in the tissues thus soiled is further proof that these hematomas contain "endometrial" tissue.

I cannot state that these ovarian hematomas of endometrial type are the only cause of ectopic pelvic adenomas.

Perforating hemorrhagic cysts of the ovary with their secondary peritoneal "implantations" are a pathologic entity as definite as that of ovarian papilloma and cancer. They are likewise a definite clinical entity which is capable of diagnosis before operation in a large percentage of the cases.

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# IS PAGET'S DISEASE OF THE NIPPLE PRIMARY OR SECONDARY TO CANCER OF THE UNDERLYING BREAST?

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When Sir James Paget wrote, in 1874, his classical account of the disease which bears his name, he described the condition clinically, rather than pathologically. Based on his own observation of fifteen cases, he outlined the course of a moist, red eczema followed by ulceration of the nipple and areola, upon which cancer of the underlying breast constantly developed. In each of his fifteen cases the breast cancer made its appearance within a year, or at most two years, after the onset of the nipple eczema.

The fact that Paget's description did not include that of the histopathology of the disease has been responsible for much of the confusion which has existed, and still exists, in the minds of surgeons and pathologists over the exact nature of Paget's disease. Without the evidence of microscopic study, it is impossible, many times, to distinguish between true Paget's disease and secondary ulceration of the skin over an advancing cancer. Exactly this mistake has been made by no less an authority than Handley,<sup>1</sup> in a recent communication. Many surgeons consider Paget's disease to be any scabbing or eczema or ulceration of the nipple which follows the clinical course described by Paget. In a well known laboratory, it is considered that "there is no such thing—it either is, or it is not, cancer." And in still a third laboratory, squamous-cell cancer of the nipple is classified with Paget's disease.

## ESSENTIAL FEATURES

It will make for accuracy in discussion of the subject to limit the term "Paget's disease" to conditions presenting the striking, unique and constant histopathology first described by Butlin<sup>2</sup> and Thin,<sup>3</sup> and later confirmed by many others. There are three essential features:

(a) *Epidermal Hypertrophy*.—The skin epithelium in the affected area (before the stage of ulceration, and ahead of the advancing margin, after ulceration begins) is increased to two or three times its normal

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1. Handley: Brit. J. Surg. **7**:183, 1919.

2. Butlin: Med. Chir. Tr., London **9**:107, 1876.

3. Thin: Tr. Path. Soc., London **32**:218, 1881.

thickness. The papillary bodies not only extend deeper, but are thicker, encroaching from the side on the connective tissue papillae to such an extent as finally almost to obliterate them. These changes are very sharply marked off from the normal epithelium at the edge of the lesion.

(b) *Subepidermal Round-Cell Infiltration.*—A very constant feature is a marked infiltration of the connective tissue under the epidermis with lymphocytes, plasma cells and occasional polymorphonuclear leukocytes. The infiltration is usually sharply limited to the affected area and is responsible for the sensation, obtained by palpation, as of a coin buried beneath the epidermis.

(c) *The So-Called "Paget's Cells."*—These are large edematous cells in the epithelium, which become vacuolated, with shrunken, pyknotic nuclei, giving the appearance of punched-out holes in the epithelium. They appear first typically in the middle layers of the epithelium and extend downward and upward. Often nearly the whole papillary body is occupied by these cells.

These Paget's cells have been the subject of much dispute. They are, of course, strictly speaking, not Paget's cells at all, inasmuch as Paget made no histologic description; but, since they form a striking and characteristic feature of the disease known by his name, they are commonly called Paget's cells.

#### VARIOUS THEORIES

They have been considered, first, to harbor a specific parasite, the cause of the disease; then to be simply degenerated epithelial cells; and, finally, by some authors, to be single-cell metastases of cancer. The earlier parasitic theory has been discarded with later careful microscopic studies under higher magnification. The theory that Paget's cells are actually cancer cells was advanced by Jacobaeus,<sup>4</sup> who believed he had found a direct connection between them and the cells of underlying breast cancer. This work has not been adequately confirmed, while von Winiwarter<sup>5</sup> and others have traced much more convincingly all stages between the prickle cells of the epithelium and Paget's cells. They do not resemble either morphologically or in behavior the cells of cancer arising either in the skin or in the breast gland, and the best opinion is that they are degenerated skin cells.

These, or similar cells, are not found exclusively in Paget's disease, though they are unusual except in this condition. We have found, for example, a group of cells morphologically identical with Paget's

4. Jacobaeus: Virchows Arch. f. Path. Anat. **178**:124, 1904.

5. Von Winiwarter: Arch. f. Dermat. u. Syph. **85**:239, 1937.

cells in the epithelium near the edge of a squamous-cell cancer of the lip, though the other typical features of Paget's disease were lacking.

Furthermore, it is very easy to mistake for Paget's cells actual cancer cells invading the epidermis from an approaching cancer. The appearance in cross-section of a strand of cancer cells invading the skin epithelium from below suggests very strongly the vacuolated, edematous appearance of a true Paget's cell. Sekiguchi<sup>6</sup> has obviously fallen into such error in interpreting some of his cases—an error against which the student should be easily warned by an observation of the frequency of just such appearances when cancer approaches the skin, often associated with the usual subepidermal cell infiltration seen in the various

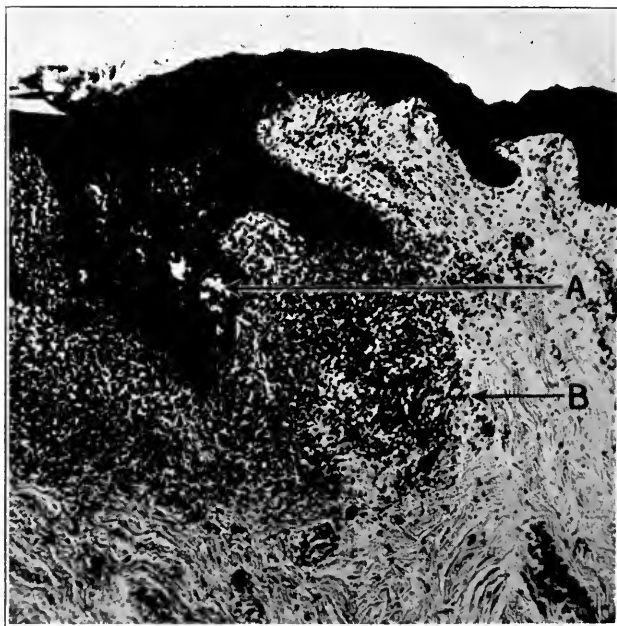


Fig. 1.—Earliest case of Paget's disease. Process limited to small areas of surface epithelium: *A*, nests of Paget's cells in hypertrophied epithelium; *B*, sharply limited zone of subepidermal-cell infiltration.

stages of ulceration over cancer, and with the well known epithelial hypertrophy also common in this process.<sup>7</sup> Sekiguchi is the most recent representative of the school holding that Paget's disease is itself malignant, drawing from his study the conclusion that "Paget's disease is primary carcinoma of the orifices of the lactiferous ducts or (in extra-mammary regions) the sudoriferous ducts." This view, we believe, is

6. Sekiguchi: *Ann. Surg.* **65**:175, 1917.

7. Kilgore: *J. Cancer Res.* **5**:291 (July) 1920.

untenable. It has often been pointed out by others that the disease exists clinically for years in other regions of the body, in some cases without ever being associated with cancer of any form, in others being followed by squamous-cell cancer. Furthermore, an unusually early case which we have had opportunity to study (Case 1) shows the typical histopathology of Paget's disease, but as yet absolutely no involvement of the ducts. It seems to us very clearly demonstrated that Paget's disease is not itself a form of cancer, nor are true Paget's cells ever migrated cancer cells.

While, therefore, cells like Paget's cells may occur under other conditions, the specific combination of epithelial hypertrophy, subepithelial round-cell infiltration and Paget's cells is so striking and so constant as to call for definite recognition; and it will remove much of the uncertainty which still exists in our knowledge of the condition to limit the term "Paget's disease" to lesions presenting this typical pathologic condition.

#### RELATION OF PAGET'S DISEASE TO CANCER OF THE BREAST

Is Paget's disease primary or secondary to the cancer of the breast which so constantly accompanies it?

Paget's original conception was that the eczema of the nipple precedes and is undoubtedly in some way responsible for the later development of cancer in the underlying breast. Since his time, authors have been, for the most part, sharply divided into two schools, one represented by Jacobaeus,<sup>4</sup> who agrees with Paget; the other, represented by Schambacher,<sup>8</sup> who asserts that the breast cancer is always present before the development of the Paget's disease, explaining the existence of the nipple condition for a long period before the cancer becomes apparent, on the well known possibility of a slow-growing scirrhous cancer remaining small for years and hence overlooked.

A consideration of well known facts makes the latter view untenable. While Paget's disease may sometimes be secondary to the cancer, events cannot always follow this sequence, for two reasons: First, typical Paget's disease occurs in regions remote from the breast and never associated with malignant disease of any kind (the illustration showing the pathology of the condition in Ewing's<sup>9</sup> text is taken from a case occurring on the buttock). Second, cases of true Paget's disease, clinically and pathologically, have been found in the nipple and areola over a breast containing absolutely no evidence of cancer. Such cases will be reported later in this paper.

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8. Schambacher: *Deutsch. Ztschr. f. Chir.* **80**:332, 1905.

9. Ewing: *Neoplastic Diseases*, Philadelphia, W. B. Saunders Company, 1919, p. 808.

It is much more difficult to prove that Paget's disease may sometimes be secondary to breast cancer. Certainly this sequence is unusual, for the skin involvement over an advancing breast cancer usually presents a histologic picture entirely different from that of Paget's disease. But in a histologic study of 500 breast cancers which I made,<sup>7</sup> one case showed the typical pathologic condition of Paget's disease with a clinical history suggesting that the cancer had long antedated the nipple condition (Case 4).

I feel sure, therefore, from a careful study of the cases to be reported here, that Paget's disease, while usually primary, may also be secondary to cancer. The principal reason for the disagreement which has existed over this point lies undoubtedly in the rarity of the



Fig. 2.—More advanced stage of surface condition: *A*, nests of Paget's cells in hypertrophied epithelium. Note the widening of the down-growing epithelial processes obliterating the connective tissue papillary bodies. *B*, zone of round-cell infiltration.

condition, most of the important contributions since Paget's time having been based on studies of one or two cases.

Through the courtesy of Dr. Joseph C. Bloodgood, it has been my privilege to study the material in the surgical pathology laboratory of the Johns Hopkins Hospital. The following case reports comprise all the undoubted cases of true Paget's disease found in a total of more than 1,500 cases of mammary disease (four cases, representing less than one third of 1 per cent. of pathologic conditions of the breast).

CASE 1 (Path. No. 24410).—*History*.—A woman, white, aged 35, who had two children, aged 10 and 7, and in whom there had been no abnormality of lactation, gave a history of slight moisture and scabbing of the left nipple for eighteen months.

*Operation*.—Complete breast and axilla operation was performed by Dr. W. A. Fisher.

*Gross Specimen*: This shows over about half of the nipple a smoothness and thickening of the epidermis which is also seen on section. Palpation gives a definite sensation of induration under this area. The change, however, is very slight.

*Microscopic Examination*: This area shows the typical histology of early Paget's disease with epithelial hypertrophy, Paget's cells and subepithelial round-cell infiltration (Fig. 1). Careful search through the gross specimen fails to reveal any evidence of tumor of any kind—only a few dilated ducts in the nipple zone. Microscopic search through blocks cut from various areas of the breast shows only these dilated ducts with some desquamated cells, but with nothing to suggest the picture of duct adenocarcinoma of the type usually seen with Paget's disease. Axillary lymph nodes show only endothelial hyperplasia.

*Comment*.—This is a case clinically and pathologically typical of Paget's disease—certainly in one of the earliest stages in which the condition has been observed. A thorough search through the breast failed to reveal any sign of gross or microscopic malignancy, either in the form of definite tumor, epithelial invasion of connective tissue, or hyperplasia of the duct epithelium. The conclusion is necessary therefore that in this instance Paget's disease occurred before the development of cancer in the breast.

CASE 2 (Path. No. 21819).—*History*.—A woman, white, single, aged 74, had had crusting of both nipples as long as she could remember—little warty crusts which would slowly form and then drop off, being renewed usually about once a year. A year ago she struck the left nipple with her hand, and it bled for a few days, so much that she wore a cloth over it. A crust then formed as usual but had been growing larger for four or five months, and the nipple had disappeared, leaving in the center of its former site the crust surrounded by an elevated zone, red and eczematous, which the patient had first noticed five months ago.

*Operation*.—Complete excision of the left breast with a zone of skin was made. There was no axillary dissection.

*Examination*.—*Gross Specimen* (Specimen sent by Dr. A. F. Robinson): On section through the nipple, the red area is seen to be very superficial with no gross cancer beneath. In the position of the nipple there is a circumscribed area about the size of the end of the little finger which gives one the impression of a depressed nipple, and beneath this a fan-shaped zone of breast stroma mixed with fat. There are no dilated ducts, no cysts, and no gross evidence of tumor.

*Microscopic Findings*: There is no evidence of cancer in the stroma. The ducts deep in the breast, however, are plugged with proliferated cells, the morphology and staining reactions of which suggest the cells of duct cancer. The characteristic changes of Paget's disease are found in the epithelium of the areola (Fig. 2). In this instance, it was not possible to trace continuously the changes from the nipple to the deeper ducts mentioned above, though it is probable that if sections had originally been taken with this in view, such continuous changes could have been traced.

*Result.*—The patient was well two years after operation; the condition of the opposite nipple being unchanged.

*Comment.*—This case, like Case 1, is typical Paget's disease, clinically and pathologically, and yet no definite tumor existed in the breast, and not enough change in the deep duct epithelium was observed to make a positive diagnosis of malignancy. It must be considered, therefore, another case in evidence that Paget's disease occurs primary to, or at least before the development of, mammary cancer.

Case 2 represents the second step in the development of cancer in the underlying breast from Paget's disease, as the process has been con-

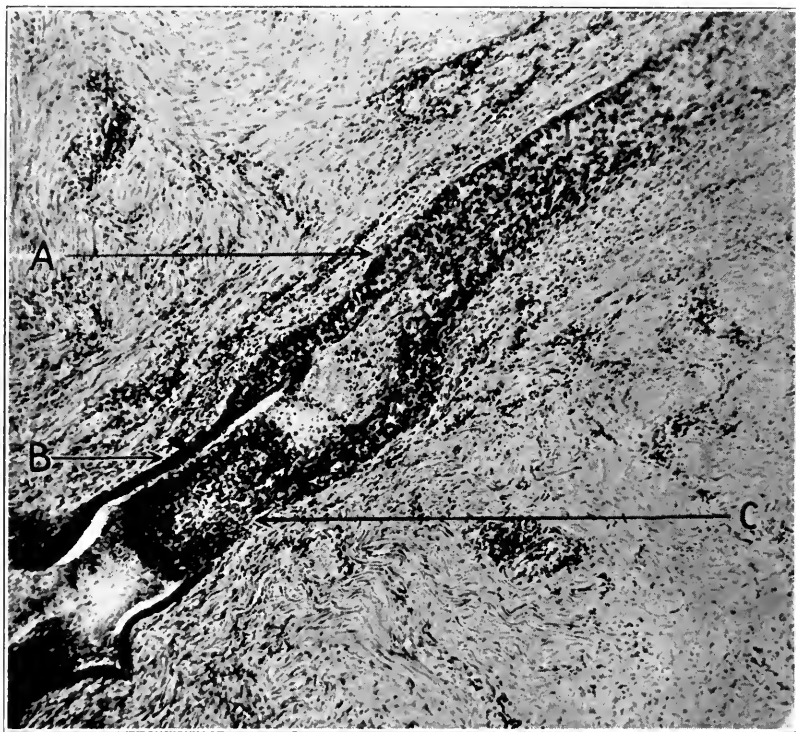


Fig. 3.—Transition in a duct between the extending disease *A* and normal duct wall *B*. At *C*, the duct curves a little so that its roof was cut in the section, obscuring the transition point on one side.

ceived by Duhring and Wile<sup>10</sup> and others. According to this view, the skin condition appears first (as in Case 1). The process then extends from the skin into the ducts in its second stage (Case 2), and finally, by excessive proliferation deep in the breast, the cells burst out of the ducts, invading the connective tissue and forming cancer.

10. Duhring and Wile: *Am. J. M. Sc.* **88**:141, 1884.



This conception is probably not far from the truth. Certainly the process can be shown to extend from the Paget's disease at the surface, down progressively along the ducts (Case 4), and it resembles in many ways the process at the surface. More than one observer has been able to see the point at which the proliferated cells plugging the ducts apparently break through the duct wall and invade the connective tissue (Jopson and Speese).<sup>11</sup> It seems unlikely, however, that a change to malignancy on the part of the epithelial cells occurs on account of over-filling of the ducts and rupture of their walls, but rather that the latter occur on account of malignant properties already developed in the cells. We have, as yet, no good explanation of when or how the change from benignancy to malignancy occurs, unless it be at the moment when the proliferative process in the ducts begins at their orifices, and that this process is from its inception a duct adenocarcinoma.

Case 2 presents clinically interesting points in the long duration of the condition of scabbing of both nipples, and the development of Paget's disease in one after trauma.

CASE 3 (Path. No. 21055).—*History*.—A woman, white, aged 72, single, had eight months before examination, first noticed itching around one nipple with some surrounding redness which gradually spread. There had been some mucous discharge from the nipple. A scab formed over the nipple and gradually replaced it.

*Examination*.—This scab with the areola around it was redder than normal and when this reddened area was picked up, it was felt to be distinctly infiltrated. No nodule could be felt in the breast.

*Operation*.—The breast was excised; axillary dissection was not performed.

Gross Pathology: The nipple was replaced by a scabbed ulcer with a surrounding zone of redness. On section, the epithelium in this zone was visibly thickened and there was definite induration under it. No tumor was found in the breast—only a few dilated ducts.

Microscopic Findings: The nipple changes presented the typical histology of Paget's disease, while the dilated ducts seen in the gross specimen presented microscopically the picture seen in the ducts of duct cancer (such as those in Case 2); but in this case also they were isolated and formed no definite tumor (Fig. 4).

*Comment*.—In this case again, true Paget's disease of the nipple had antedated any definite tumor in the breast, and the reasonable presumption is that it had antedated the early changes seen in the ducts. The process is similar in its stage of development to that observed in Case 2.

CASE 4 (Path. No. 22629).—*History*.—A widow, colored, aged 43; who had had six children—the youngest child being 7 years old, and two miscarriages, had two years before, received a bruise in the upper, outer quadrant of the left breast. Six months later she first noticed a lump at the site of injury. Three months ago, that is, fifteen months after she first noticed the lump, it broke through the skin spontaneously. She had noticed gradually increasing retraction of the nipple for several months and, one month ago, for the first time, she noticed ulceration at the nipple.

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11. Jopson and Speese: *Ann. Surg.* **62**:212, 1915.

*Operation.*—A complete operation for cancer was performed.

*Gross Specimen:* This shows the nipple replaced by an ulcer, and the areola at the site of the nipple retracted. On section, the ulcerated cancer in the upper outer quadrant is at least 4 cm. from the nipple, but extending from the nipple in the direction of the tumor are seen dilated ducts filled with yellowish material. The suggestion in the gross specimen is that the nipple ulceration has been caused by the discharge of irritating material from these ducts.

*Microscopic Findings:* The epithelium at the margin of the nipple ulcer shows the typical pathologic condition of Paget's disease, and the mouth of one duct is found plugged with proliferated cells resembling those of duct cancer. The plug of cells extends down the duct 2 or 3 mm. and ends in an abrupt



Fig. 4.—Process as it appears when it has extended to the deep ducts of the breast. The ducts are plugged with cells and present an appearance similar to that of duct cancer: *A*, vacuolated cells, resembling Paget's cells; *B*, zone of round-cell infiltration.

transition to apparently normal duct epithelium (Fig. 3). No other plugged ducts are found either in the nipple section or in blocks taken between this area and the tumor.

*Comment.*—In this case the tumor had been present at least fourteen months and had ulcerated through the overlying skin two months before the nipple ulceration was noticed. Either this was faulty observation on the part of the patient, or the cancer was present before the Paget's disease of the nipple. I do not believe the patient's observation was faulty for three reasons: (1) Her attention had been called to the nipple by its retraction, and ulceration would

undoubtedly have been observed. (2) Experience shows that patients are quick to observe changes in the nipple. In a study of 500 breast cancers which I<sup>17</sup> have made, no nipple epithelial change was found pathologically which had not been observed by the patient as eczema or ulceration. (3) The pathologic condition of this specimen itself suggests that the Paget's disease is recent, for the characteristic proliferative changes in the ducts have progressed only 1 or 2 mm. below the nipple epithelium.

I believe that the obvious inference is correct, namely, that the Paget's disease followed on a primary breast cancer, but I am not justified in making a positive commitment on the evidence of one case. My justification in thus reporting and discussing a single case presenting this sequence of cancer first, and Paget's disease second, rests on the rarity of the condition, but four instances of true Paget's disease having been found among 1,100 breast cancers observed during twenty-five years.

#### OTHER NIPPLE ULCERS

Ulceration of the nipple may be the first sign by which a deeper cancer manifests itself, a cancer which may not be found as a palpable tumor for months or years after the nipple change begins. The cancer may be so deep in the breast that excision of the nipple and surrounding zone of breast and skin would fail to include any of the cancer and so lead to erroneous diagnosis. This is illustrated by the case herewith reported:

*CASE 5* (Path. No. 7107, not true Paget's disease).—*History*.—A woman, white, aged 55, married, with four children, the youngest 27, had had cracked nipples during her lactations years before. Eight months before examination the left nipple had shown slight erosion and had scabbed over, the scab falling off every few weeks. No tumor was felt in the breast. The record contained no description of the condition of the areola around the nipple.

*Operation*.—Excision of the nipple and zone of breast and skin was made.

*Microscopic Examination*: This showed only chronic and acute inflammation. No cancer was found.

*Result*.—Three years later this patient was operated on for an infiltrating cancer near the scar in the breast, and died one month later from cerebral metastases. There is no good reason to doubt that the cancer already existed at the time of the first operation, was the cause, and not the result, of the nipple condition, and would have been found on pathologic examination had the entire breast been removed.

*Comment*.—A case almost identical in its history with Case 5 has been reported by Martin,<sup>12</sup> in which a woman, aged 61, presented crusted nipples for one year. The nipple was excised and pathologic examination revealed only simple inflammatory changes, which were mistakenly diagnosed "Paget's disease." Two years later, the patient returned. Examination revealed a hard, irregular mass beneath the scar in the breast. It proved to be scirrhous cancer which had already metastasized to the axilla.

It seems to me that the lesson in Case 5 and of Martin's case is perfectly clear, namely, that any persistent eczema or ulceration of the nipple, whether

12. Martin: Ann. Surg. 64:725, 1916.

true Paget's disease or not, requires, for the patient's safety, excision of the entire breast, not of the nipple alone.

#### SUMMARY

1. From the point of view of intensive study of the condition, the term "Paget's disease" should be limited to those lesions presenting the typical histology: (a) epithelial hypertrophy; (b) subepithelial round-cell infiltration; (c) Paget's cells.

2. All the cases of Paget's disease reported, however, as well as Case 5 and Martin's case (not true Paget's disease), emphasize the importance of removing the entire breast for any chronic, persisting nipple eczema or ulcer, regardless of the apparent presence or absence clinically of deeper breast changes. At operation, the decision for or against axillary dissection should depend, not on frozen section diagnosis of the nipple condition between true Paget's and other eczemas, but on the pathologic condition of the breast itself. The best procedure is amputation of the breast with a wide zone of skin, using the knife cautery in cutting across the lymphatics leading to the axilla, and proceeding immediately to the axillary dissection if any gross or frozen section evidence of cancer be found in the excised breast.

3. Three cases are reported demonstrating that Paget's disease is usually primary to cancer of the breast which has been found constantly in association with it. In one of these cases no change whatever had as yet occurred in the breast, and in two cases the early changes of what was probably duct carcinoma had begun when the breast was excised. A fourth case is reported in which all the evidence of history and pathology points to a reversal of this order, the cancer in the breast apparently originated first, and was followed by Paget's disease of the nipple. If the deductions in this case are correct then both schools in the controversy over the primary or secondary nature of Paget's disease have been right, since either order of events may occur.

4. Three stages in the process by which we believe cancer in the underlying breast develops from Paget's disease are illustrated by the various cases reported. Figure 1 shows the condition, limited to the surface; Figure 3 shows the condition in course of extension down the ducts from the nipple<sup>13</sup> while Figure 4 is from a case in which the process had extended to the deep ducts. The picture resembles closely that of duct cancer. The final stage in which the cells plugging these deep lying ducts break out into the connective tissue and give rise to

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13. Figure 3 is from the case in which deep cancer preceded the Paget's disease, but it is obvious that, once started, the Paget's disease is behaving as it usually does, extending down the ducts from the surface.

scirrhus cancer was not found in this series but has been observed by other authors.<sup>11</sup>

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NOTE.—A very complete bibliography of the literature of Paget's disease may be found in Deaver and McFarland: *The Breast: Its Anomalies, Diseases and Their Treatment*, Philadelphia, P. Blakiston's Son & Co., 1916, p. 696. Since the publication of this bibliography, the following articles have appeared in addition to those already referred to:

Fowler: Tumors of the Areola and Nipple of the Breast, *Med. Times* **45**:195, 1917.

Burns: Paget's Disease and Carcinoma, *Edinburgh M. J.* **17**:161, 1916.

Potter: Extramammary Paget's Disease, *Jour. Cutan. Dis. incl. Syph.* **34**:306, 1916.

Harett: Case of Paget's Disease Treated by Radiotherapy, *Jour. de radiol. et d'électrol., Par.* **3**:416, 1918-19.

Trimble: Eczema of the Nipples, *Arch. Dermat. and Syph.* **13**:253, 1920.

Hartmann: *Maladie de Paget*, *Rev. gén. de clin. et de thérap.* **31**:581, 1917.

Thorndike: Dermatitis Simulating Paget's Disease, *Boston M. and S. J.* **77**:122, 1917.

Brunsgaard: A case of Paget's Disease, *For. med. Selsk. i Kristiania*, 1916, p. 149.

## SQUAMOUS-CELL CARCINOMA OF THE URINARY BLADDER

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Various investigators have shown that columnar and transitional epithelial linings in certain organs of the body are capable of extensive epidermization when a protective covering is desirable. Broders<sup>1</sup> has found a transition from a columnar to a squamous covering in everted, prolapsed irritated uteri. Rokitsansky<sup>2</sup> describes a stage of epidermoid metaplasia of the mucous membrane of the urinary bladder as cholesteatoma. Kretschmer<sup>3</sup> collected from the literature the reports of forty-four cases of leukoplakia of the bladder, ureter, and pelvis of the kidney, showing that the urinary tract, normally lined by transitional epithelium, is capable of developing a squamous-cell surface. The traumatized exposed surfaces of extrophied bladders practically always show areas of epidermization.

Hallé<sup>4</sup> holds that this epithelial transformation of the mucosa of the urinary passages results from chronic inflammation, either simple or due to stones. He reports seven such cases in the bladder, in all of which there was cystitis; in four there were stones. Similar cases, associated with calculi, are reported by Cabot,<sup>5</sup> Nogués<sup>6</sup> and Verrière.<sup>7</sup> Albarran<sup>8</sup> mentions the occurrence of epidermization following long-standing cystitis. Morris<sup>9</sup> describes the conversion, under prolonged irritation, of the lining of a ureter, which for a long time had been the resting place of calculi, to a thick and wrinkled membrane which histologically was divisible into cutis vera and epidermis. While chronic

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1. Broders, A. C.: Personal communication.

2. Rokitsansky, C.: *A Manual of Pathologic Anatomy*, Philadelphia, Blanchard and Lea, **1**:306, 1855.

3. Kretschmer, H. L.: Leukoplakia of the Bladder and Ureter, *Surg., Gynec. & Obst.* **31**:325-339 (Oct.) 1920.

4. Hallé, N.: Leucoplasies et cancroïdes dans l'appareil urinaire, *Ann. d. mal. d. org. génito-urin.* **14**:481, 577, 1895.

5. Cabot, A. T.: A Case of Cystitis with the Formation of a Thick Epidermal Sheet in the Bladder, *Am. J. M. Sc.* **101**:135-142, 1891.

6. Nogués, P.: Trouble des urines du la présence exclusive des cellules épithéliales, *Ann. d. mal. d. génito-urin.* **17**:585-589, 1899.

7. Verrière, A.: Deux cas de leucoplasie de la muqueuse vésicale, *Lyon méd.* **95**:116-125, 1910.

8. Albarran, J.: *Les tumeurs de la vessie*, Paris, Steinheil, 1892.

9. Morris, H.: *Surgical Diseases of the Kidney and Ureter*, London, Cassell, **2**: 1901.

irritation is a common cause of the condition, it is not an essential factor in all cases. Leber<sup>10</sup> reports the case of an infant of 4 months in whom the epithelial lining of the pelvis of the kidney was composed of many layers of cells showing cornification; a similar condition was found in the infant's eye. This case suggests a congenital origin. Lecène<sup>11</sup> holds that the process in these cases is due, not to chronic inflammation, but to developmental changes in the genito-urinary tract. Wilson<sup>12</sup> suggests that epidermoid growths of the pelvis of the kidney may be due to inclusions of ectodermal cells carried from the rectum to the kidney by way of the cloacal wall. Malignant transformation of this epidermized epithelium is not an uncommon event. According to Ewing,<sup>13</sup> squamous metaplasia which affects the cells before the tumor develops accounts for the presence of epidermoid carcinoma in unusual

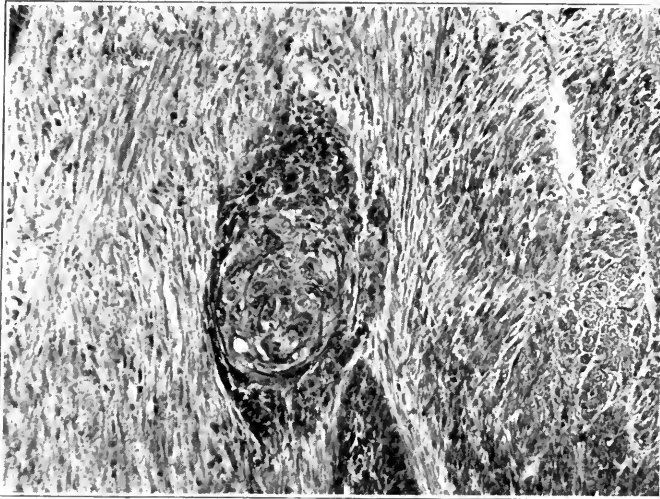


Fig. 1 (Case 2, 147667).—Isolated malignant focus with epithelial pearl growing between muscle bundles in the vesical wall;  $\times 100$ .

situations. Typical squamous-cell carcinoma, which has all the characteristics of this disease on the cutaneous surface, is occasionally found in the genito-urinary tract.

10. Leber, T.: Ueber die Xerosis der Bindehaut und die infantile Hornhautverschwrung nebst Bemerkungen ber die Entstehung des Xerophthalmus (Abstract), *Deutsch. med. Wchnschr.* **10**:206, 1884.

11. Lecne, P.: Un cas de leucoplasie du bassint, *J. d'urolog. md. et chir.* **1**:129-137, 1913.

12. Wilson, L. B.: The Embryogenetic Relationships of Tumors of the Kidney, Suprarenal, and Testicle, *Ann. Surg.* **57**:522-535, 1913.

13. Ewing, J.: *Neoplastic Diseases, a Textbook on Tumors*, Philadelphia, W. B. Saunders Company, 1919.

Albarran<sup>14</sup> notes that vesical leukoplakia may become transformed into true epidermoid cancer. Hallé<sup>4</sup> also is of the opinion that these tumors become engrafted on epidermized plaques. Buerger,<sup>15</sup> in describing squamous-cell tumors of the bladder, states that the mucous membrane in the immediate neighborhood often shows leukoplakia. A number of squamous-cell carcinomas of the ureter and of the pelvis of the kidney have been described. Kischensky<sup>16</sup> cites a case of squamous-cell epithelioma of the pelvis of the kidney with extensive metaplastic changes in the surrounding tissues and extending down the ureter into the bladder.

Primrose<sup>17</sup> reported a case of squamous-cell carcinoma of the renal pelvis complicated by a stone in a horse shoe kidney. Scheel<sup>18</sup>

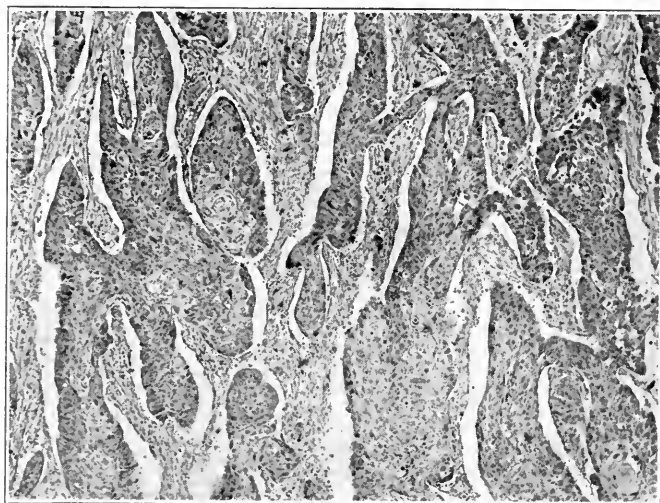


Fig. 2 (Case 3, 203917).—Wide spread extension of tumor masses through the outer layers of the wall of the bladder;  $\times 50$ .

describes a combination of papilloma and squamous-cell epithelioma of the pelvis of the kidney with multiple metastases. The metastases

14. Albarran, J.: Neoplasmes primitifs du bassin et de l'uretère, *Ann. d. mal. d. org. génito-urin.* **18**:918-954, 1900.

15. Buerger, L.: *The Pathological Diagnosis of Tumors of the Bladder with Particular Reference to Papilloma and Carcinoma*, Surg., Gynec. & Obst. **21**: 179-198, 1915.

16. Kischensky, D. P.: Primärer Plattenepithelkrebs der Nierenkelche und Metaplasie des Epithels der Nierenkelche, des Nierenbeckens und des Ureters, *Beitr. z. path. Anat. u. z. allg. Path.* **30**:348-369, 1901.

17. Primrose, A.: Squamous-Cell Carcinoma of the Kidney, *J. A. M. A.* **75**:12 (July 3) 1920.

18. Scheel, P. F.: Ueber ein eigenartiges Kankroid der Niere, *Virchows Arch. f. path. Anat.* **201**:311-325, 1910.



showed only cells of the squamous type. In 195 tumors of the kidney observed at the Mayo Clinic there was one squamous-cell carcinoma of the pelvis of the kidney. Garceau<sup>19</sup> cites a case of Adlers of epidermoid carcinoma of the ureter. Rundle<sup>20</sup> also describes a very extensive tumor of this type originating in the lower end of the ureter and markedly infiltrating the surrounding tissues and metastasizing to the liver and lungs.

Cases of epidermoid carcinoma of the bladder are not uncommon. Albarran found four cases in a review of 125 cases of vesical tumor. Three of the patients died very shortly after operation; one was well four months later. Hallé collected the reports of a number of cases from the literature and gives the history of four patients observed at

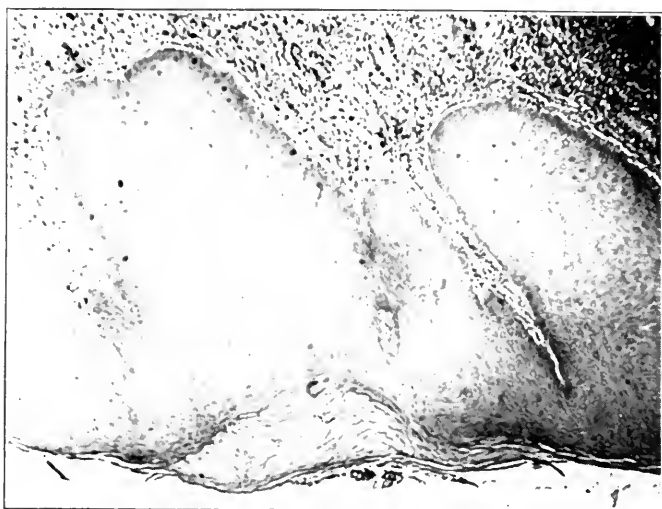


Fig. 3 (Case 3, 203917).—Epidermization of mucosa in regions adjoining squamous-cell carcinoma;  $\times 50$ .

the Necker hospital. In three of these four patients the condition was inoperable; the patients died shortly after entering the hospital. The fourth patient was operated on and died immediately after the operation. Montfort<sup>21</sup> collected seven cases: in three, there was an extension to the rectum; in a fourth, the growth had spread through the dome of the bladder, a mass "the size of an apple" being found in the

19. Garceau, E.: Tumors of the Kidney, New York, D. Appleton & Co., 1909.

20. Rundle, H.: Epithelioma of the Ureter Causing Hydronephrosis, Tr. Path. Soc., London, **47**:128-132, 1896.

21. Montfort, E.: Rôle de la prostate dans la production des tumeurs epitheliales infiltrées de la vessie, Thèse, Paris, Rousset, 1903.

adherent great omentum. Montfort states that in all his cases the tumor was complicated by marked cystitis. Of 113 neoplasms of the bladder, Buerger<sup>15</sup> regarded five as squamous-cell carcinoma. He states that they rapidly penetrate the muscular coats and that they offer a very poor prognosis for the patient. Fenwick<sup>22</sup> cites two cases, one in which a benign papilloma was surrounded by a dense squamous-cell epithelioma. There was marked infiltration of the wall of the bladder, the vesical surface being flat and necrotic. The second case was that of an extremely large tumor arising from the posterior wall of the bladder and having a history of only six months' duration. Geraghty<sup>23</sup> states that squamous-cell carcinoma is exceedingly rare.

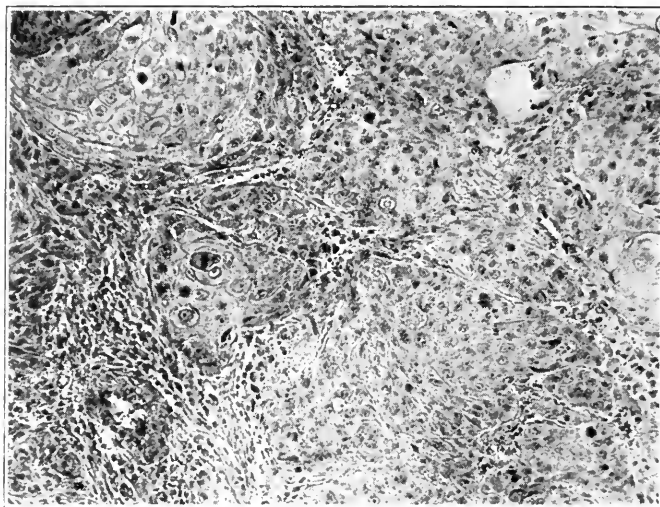


Fig. 4 (Case 3, 203917).—Solid masses of tumor cells with many epithelial pearls. A number of malignant cells show two or even three deeply staining nucleoli;  $\times 100$ .

He found only one case in 180 epithelial tumors of the bladder observed in Johns Hopkins Hospital. Busse<sup>24</sup> describes a case associated with a papillomatous growth in the ureter and extensive metastases. Cassanello<sup>25</sup> reports two cases, in one of which the his-

22. Fenwick, E. H.: *A Handbook of Clinical Electric-Light Cystoscopy*, London, Churchill, 1904.

23. Geraghty, J. T.: Quoted by Cabot H.: *Modern Urology*, in *Original Contributions by American Authors*, Philadelphia, Lea and Febiger, 1918.

24. Busse, O.: *Geschwulstbildung in den grossen Harnwegen*, *Virchows Arch. f. path. Anat.* **164**:119-132, 1901.

25. Cassanello, R.: *Contributo allo studio dell' epithelioma epidermoidale della vesica con speciale riguardo all question del chorion epithelioma vesicae*, *Folia urolog.* **3**:509-540, 1909.

tologic structure of the growth greatly resembled a chorio-epithelioma. He states that the growth in his cases was very malignant, rapidly and extensively infiltrating the surrounding tissues.

The majority of squamous-cell carcinomas of the bladder are flat and ulcerated, extensively involving the wall. The preoperative symptoms are generally of short duration. In most cases the symptoms are mild and do not give a correct indication of the extent of the condition. Metastases occur, but not so frequently nor so extensively as the extent and appearance of the local lesion would indicate. Squamous-cell tumors, in general, especially those showing marked differentiation, do not metastasize readily. The metastases in most cases are confined to the local lymph areas. Sanderson<sup>26</sup> has observed a case of squamous-cell epithelioma of the penis, with metastases to the inguinal nodes. Five years later there had been no further metastases.

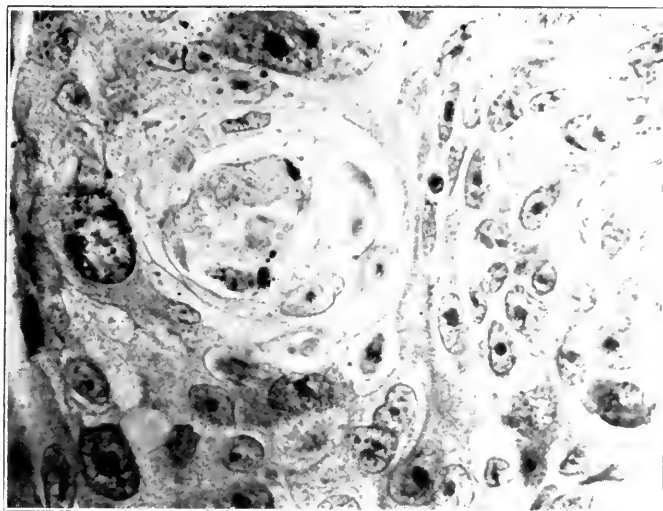


Fig. 5 (Case 3, 203917).—Atypical mitotic figures, irregularity in size and staining qualities of cells and large deeply staining nucleoli, "one-eyed malignant cells" (Broders);  $\times 500$ .

Mitotic figures are fairly common in epidermoid tumors of the bladder, but they do not always indicate a high degree of malignancy. Broders<sup>1</sup> holds that mitotic figures are not so important a criterion of malignancy in epithelioma as they are in connective tissue tumors. Evans<sup>27</sup> showed that in sarcoma and myosarcoma the malignancy varied directly with the number of mitotic figures. Broders has seen

26. Sanderson, F. R.: Personal communication.

27. Evans, N.: Malignant Myomata and Related Tumors of the Uterus, Surg. Gynec. & Obst. **30**:225-239 (March) 1920.

patients with epithelioma of the penis with numerous mitotic figures alive and well three years after operation in contrast to other patients in whom mitotic figures were rare who died shortly after operation from recurrence of tumor.

Six cases of squamous-cell epithelioma in 333 neoplasms of the bladder were observed in the Mayo Clinic from Jan. 1, 1910, to Jan. 1, 1920. These six cases are of interest not only because of their extreme malignancy, but because of the insidious onset and the lack of definite symptoms. The growths are readily recognized histologically, and this is of distinct prognostic importance.

CASE 1 (60036).—Mrs. M. P., aged 45, came to the clinic, Oct. 13, 1911, because of frequent attacks of hematuria during the last four months. She had not had pain but had lost 30 pounds in weight in the four months.

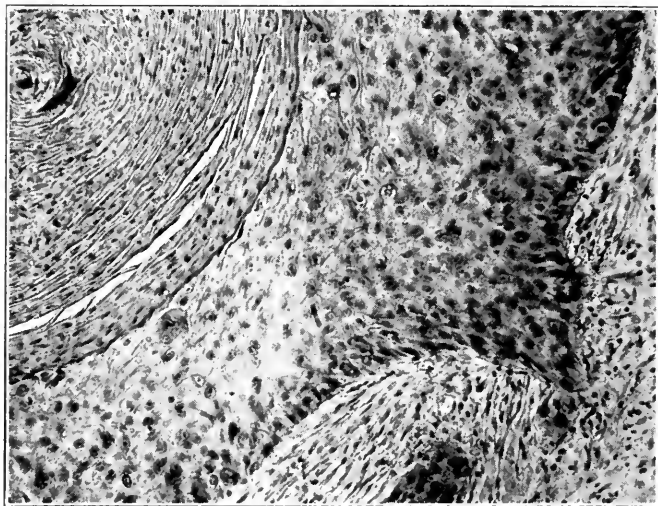


Fig. 6 (Case 5, 313258).—Wide spread hyalinization, showing layered cleavage planes of hornified areas;  $\times 100$ .

The general physical examination was negative. The cystoscopic examination showed a flat nodular growth 3 cm. in diameter on the upper left wall of the bladder. At operation an indurated broad base carcinoma was found, and a transperitoneal resection of the upper third of the bladder was performed. The patient readily recovered from the operation. She returned to the clinic two years later with a small recurrent growth which was removed by fulguration. Seven years after fulguration and nine years after operation she is well, and has no signs or symptoms of recurrence.

The excised tumor was rough, flat, firm, and friable, 2 cm. by 3 cm., and extended down, out into surrounding submucous tissues. It was covered by keratinized tissue 3 mm. thick. This readily flaked off. Histologic examination revealed a typical squamous-cell carcinoma. It consisted of branching columns and large solid masses of only moderately differentiated epithelial cells. The

cells, in the main, were large, irregular, pale and unevenly stained, with prominent nucleoli. In the larger masses the peripheral cells were smaller and more deeply stained. The central or older cells showed degenerative changes and in some areas were arranged in circular whorls of completely hyalinized cells—the so-called epithelial pearls. A few areas showed a tendency toward papillomatous formation, the cells arranging themselves around a connective tissue axis and assuming a palisade formation. Large masses and strands of malignant cells projected into the submucous and muscular tissue and at times isolated epithelial pearls were seen pressed between muscular and fibrous bands. There was a marked round-cell infiltration, mostly plasma cells, not only throughout the malignant area but also in the submucous and muscular coats of the bladder. A large number of mitotic figures, the lack of cellular differentiation, and the irregularity and varying size of the cells, with the local extension, indicated a high degree of malignancy.

CASE 2 (147668).—Mrs. W. B., aged 54, was examined in the clinic, Dec. 10, 1915. She had been troubled with frequency of micturition and periodic

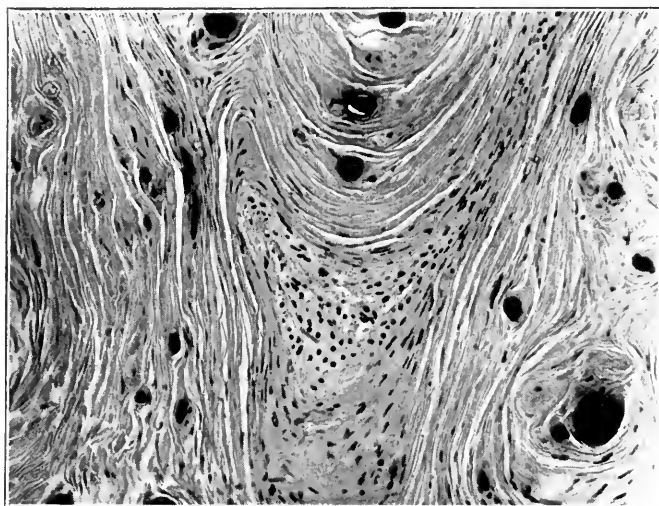


Fig. 7 (Case 5, 332791).—Extreme hyalinization of tumor masses:  $\times 100$ .

irritability for twenty-eight years. The urinary trouble started directly after a difficult childbirth. Twenty-four years before examination she had had several attacks of severe pain in her right loin; the last one had occurred twenty years before. For the last three years, frequency and dysuria had been slight and infrequent. Two months before there had been a marked exacerbation of the urinary trouble and a slight terminal hematuria. The recent bladder trouble was more severe and "different" from that of the last twenty-eight years.

On physical examination, a hard, tender mass 4 cm. in diameter was felt in the suprapubic region. Cystoscopy revealed a flat growth 6 cm. in diameter on the right half and dome of the bladder. At operation an extensive indurated tumor was found extending from the dome to the right base. A transperitoneal extirpation of the right half of the bladder was performed and the right ureter ligated. The patient convalesced satisfactorily. Four months later, a small recurrence of the tumor was fulgurated. After two months, the recurrence

persisting, the bladder was reopened and three small growths cauterized. Six months later, one year after the first operation, the patient died from recurrence.

The tumor was 5 cm. in diameter: its surface was ulcerated. It involved the entire wall of the bladder, and in one area it extended to the peritoneum. In places the growth was fibrous and dry with a tendency to split along cleavage planes, as is often seen in papillary carcinomas. Microscopic examination revealed in certain areas a high degree of differentiation with extensive hyalinization and pearly body formation (Fig. 1). In other areas the cells were large, irregular, and active with no tendency toward epidermization. There were many mitotic figures and a moderate round-cell infiltration.

CASE 3 (203917).—Mr. W. A. P., aged 32, came to the clinic, Aug. 4, 1917, because of pain in the lower right abdomen, and moderate frequency and dysuria of three months' duration. During this time he had lost 20 pounds in weight. Cystoscopy revealed a necrotic mass 6 cm. in diameter on the dome of the bladder. At operation a large carcinoma of the dome and posterior wall was discovered. The mucosa of the remainder of the wall of the bladder

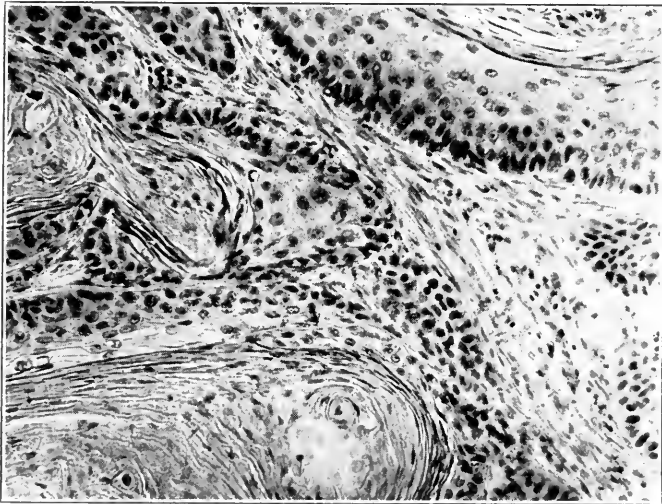


Fig. 8 (Case 6, 332791).—Extensive pearly body formation with many rapidly growing malignant cells;  $\times 100$ .

was moderately necrotic. A transperitoneal resection of the upper third of the bladder was performed. The patient recovered normally, but died six months later from extensive local recurrence.

The tumor was flat and firm with an ulcerated necrotic surface 6 cm. in diameter. The sides sloped outward to meet the mucosa of the bladder, the infiltration extending deeply into the muscular coats. In one section the neighboring mucosa was covered by an area of leukoplakia. The histologic examination revealed marked round-cell infiltration. The cells were only slightly differentiated, although only moderate pearly body formation was seen. The individual cells were partly hyalinized in a few areas and retained their rounded contours, large nuclei, and prominent nucleoli. There was marked connective tissue reaction: in some sections this completely isolated parts of the tumor (Figs. 2, 3, 4 and 5).

CASE 4 (305220).—Mrs. S. R. P., aged 31, was examined in the clinic, Feb. 4, 1920. Eleven months before, while pregnant, she had had moderate hematuria for one week. Three months later she was delivered of a normal baby. Ten days later she passed a small amount of gravel with severe pain. She was cystoscoped by her home physician who told her that she had a papilloma of the bladder. He fulgurated the growth nine times in six months. Pain over the lumbar region with swelling of the left thigh and leg appeared three months before examination. The pain had been very severe and hematuria marked during the last week.

Physical examination revealed discrete, firm, movable, enlarged glands above the clavicle, in the left iliac region, and in the abdominal fat. A mass 2 cm. by 6 cm. was felt through the vagina in the region of the bladder. On cystoscopic examination a flat necrotic mass was found spread over the left base, left ureteral orifice, and anterior wall of the bladder. The metastases and local condition obviously made the growth inoperable. The patient rapidly became weaker and died five months later.

Examination of a specimen removed during the cystoscopic examination revealed squamous-cell carcinoma of a high degree of malignancy. The cells were large and irregular with active nuclei. There was practically no differentiation, the cells showing only a slight tendency toward cornification and circular disposition.

CASE 5 (313258).—Mrs. G. D. K., aged 47, was examined in the clinic, April 21, 1920. She had been troubled with slight incontinence, which started following childbirth twenty-nine years before. Two unsuccessful attempts had been made to repair her urethra, one eighteen years before, the other four years before. She had not had hematuria or dysuria, but during the last year incontinence had increased with some frequency.

On examination a lacerated perineum and urine dripping from the urethra were found. A firm, fixed mass 10 cm. in diameter was palpated in the region of the bladder. Cystoscopy revealed a tumor involving the entire bladder except the anterior wall. An exploratory operation was performed, and 720 mg. hours of radium given. The bladder and surrounding tissues were extensively involved in the growth. The patient did not recover her strength after the operation and died four months later.

The specimen removed was gray, firm, and compact. It was markedly fibrous throughout. Areas of complete differentiation alternated with sections of malignant tumor cells. In the latter areas the cells were large, well formed and packed closely, projecting in finger-like masses into the surrounding tissue. In some areas hyaline and cystic degeneration of individual cells was found (Fig. 6). Areas of round cells were quite numerous.

CASE 6 (332791).—Mr. W. C., aged 67, came to the clinic, Sept. 6, 1920. He complained of weakness and loss of weight of one year's duration. He had lost 90 pounds, mainly during the last three months, and had had dysuria, frequency, and moderate difficulty in micturition. For three weeks he had complained of a sense of discomfort over the pubes.

The prostate was found to be enlarged, irregular, firm, and tender. The roentgenograms contained a shadow in the region of the bladder 5 cm. by 6 cm. An exploratory operation was performed and a rough, flinty stone corresponding to the shadow was removed. The entire wall of the bladder was covered with a soft, grayish tumor. Large masses of the growth were scooped out and the bladder closed loosely around a tube. The patient died two days later. At necropsy, bilateral obstruction of the ureter was found. On the left side was

a pyonephrotic kidney with multiple abscesses, and on the right pyonephrosis with atrophy of the kidney. The wall of the bladder was infiltrated with a grayish tumor; on the posterior superior wall was a diverticulum 4 cm. in diameter. A stone 2 cm. by 5 cm. was found in the prostatic urethra.

Histologic examination of the growth revealed almost complete cellular differentiation; the tumor was a mass of hyalinized tissue. The cornification had taken place in long bands and multiple large rouleaux with only scattered areas of flattened tumor cells. Throughout the cornified areas were many small deposits of calcareous degeneration. Cleavage lines were easily seen, especially in areas where the formation was separated during the preparation of the specimen (Figs. 7 and 8).

#### COMMENT

Three of the six patients were seen in an operable condition an average of three months after the first appearance of symptoms. One of these had a recurrence four months after operation, and died eight months later; one died six months after operation, and one, the only patient who did not die from the disease, is living and well nine years after operation. The other three patients had inoperable tumors. In the inoperable cases, there had been symptoms referable to the carcinoma for an average of twelve months.

Two of the six patients had histories of urinary trouble with undoubted cystitis for more than twenty-eight years. This corresponds to the preoperative history of patients with leukoplakia and may represent such a preexisting condition, the aggravation or exacerbation of symptoms indicating the onset of malignancy. In only one patient (Case 6) was the tumor complicated by stone formation. The extreme hyalinization pointed to a long-standing condition, possibly a simple epidermization, even though the period of symptoms had been short. It is remarkable that with such an extensive local growth there were no metastases. This is probably due to the low incidence of metastasis from tumors of such a high degree of cellular differentiation.

The average age of the patients was 46 years, strikingly lower than the general average age of patients with carcinoma of the bladder. The incidence of sex, four women and two men, is also exceptional and contrary to the usual occurrence in which the male outnumbers the female three or four to one.

Case 1 indicates that a permanent cure is possible. The tumor in this case was highly malignant. An early resection was successful in spite of the local extension and the extreme malignancy of the tumor.

In most cases the insidious onset and the rapidity of the growth make squamous-cell tumor of the bladder an exceptionally dangerous disease.



## SUMMARY

1. Under certain conditions, such as trauma and infection, the mucosa lining the urinary tract undergoes extensive epidermization.

2. These areas of metaplasia, or, as they are termed, leukoplakia, have a predisposition to form squamous-cell carcinomas of a very high degree of malignancy.

3. Six cases of squamous-cell carcinoma of the bladder are reported; five of the patients died shortly after the disease was discovered.

## CANCER OF THE BREAST \*

BYRON B. DAVIS, A.B., M.D.

OMAHA

In a former contribution, I reported 166 cases of mammary carcinoma in which operation was performed by radical methods, with one immediate death from postoperative pneumonia. Letters were sent out to the 165 surviving patients, or members of their families, and 101 replies were received. Of the 101 answers received sixty-three stated that the patient had been free from the disease for periods of from three to twenty-one years. Of the remaining thirty-eight patients, two were living but were suffering from recurrence, and thirty-six were found to have died of local or disseminated cancer. Four of these were not considered by their relatives to have died of cancer, but from the descriptions of the symptoms, death was obviously due to cancer, and was so considered.

Today, I am able to add twenty-four more cases, in which questionnaires were recently sent. Answers have been received from twenty-one patients. Twelve are reported to be in good health, and apparently without a return of the disease. Nine are reported dead. The sister of one of these reports the death as from tuberculosis; but it is fair to infer that it was pulmonary carcinoma, and I feel justified in counting it as a death from cancer. Still another died of influenzal pneumonia only a few weeks after I had operated on her for an extensive local recurrence, with a very grave prognosis. Though pneumonia was the immediate cause of death, the postoperative condition was so grave that it seems only fair to count this among the unsuccessful cases, so it is included on that side of the ledger. Of the remaining seven deaths, the lesions in six cases were very extensive at the time of operation, two of them having adhesions both to skin and to pectoral fascia; and all showing extreme involvement of the axillary glands. Of the nine fatal cases, seven were considered at the time of operation very bad risks.

Combining the last twenty-four with the 166 previously reported, we have 190 cases for consideration. Of these it has been possible to trace only 122; sixty-eight I have not been able to get replies from. Of the 122 cases traced, seventy-five were free from recurrence for from three to twenty-one years, and forty-seven were reported as having died or as suffering from a hopeless recurrence. Computing the

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\* Read in the cancer symposium at the Clinical Congress of Nebraska Surgeons, March 3, 1921.

results only on the 122 cases heard from would show 62 per cent. well from three to twenty-one years after the operation. This is manifestly too high. Computing the results on the 190 cases in which operation was performed would show 39.5 per cent. well for from three to twenty-one years. This is too low. The truth apparently lies somewhere between these figures.

No one any longer reports his cancer patients as cured. A three-year limit or a five-year limit is purely arbitrary. It is conceded that each year elapsing after a radical operation, without a return of the disease, makes recurrence less likely.

I have had patients remain apparently well for five, eight, nine or ten years, and then report with a recurrence from which they soon died.

The length of time the existence of the lump has been known and the apparent extent of the disease at the time of operation are not nearly such good indexes of the prognosis as one would, theoretically, suppose. The discovery of the lump is usually accidental, bearing no definite relationship to the date of the beginning of the disease, or to the extent of its dissemination. Some of the patients with apparently extensive mammary and axillary involvement have been free from recurrence for many years, and *per contra* several patients with only a small lump in the breast, recently discovered, with no apparent extension to the axillary or other glands, have died of early and rapid recurrence. There are degrees of malignancy. The two cases herewith reported are illustrative of the fact that it is not easy to formulate a prognosis in advance.

#### REPORT OF ILLUSTRATIVE CASES

CASE 1.—Mrs. B., aged 46, had first noticed a lump in her right breast only six weeks before I saw her. In this short time ulceration of the skin had already begun, and there was extensive axillary involvement, which was only partly cancerous, it being largely inflammatory. An extensive radical operation was performed, Sept. 3, 1917. Five months later she returned with no local recurrence on the side operated on, but with extensive cancerous disease of the opposite (left) breast. Radical operation was performed on the left side, Feb. 13, 1918, and the left axillary glands were found invaded. She is reported to have died of extensive recurrence over the entire thorax, Oct. 28, 1918, about fifteen months after she first discovered the small lump in her right breast.

Case 2 is another case that shows the opposite tendency.

CASE 2.—Mrs. R. presented a very extensive involvement of the left breast with massive infiltration of the axillary glands. It was so bad I hesitated about operating, considering the prognosis absolutely grave. The operation was performed Jan. 15, 1918. Dr. C. C. Green, of Beaver City, Neb., reported her well and free from recurrence Jan. 30, 1921.

## DEGREES OF MALIGNANCY

Why one breast cancer is so virulent and another so mild we do not know. There is no doubt that the cell energy in one case is so great it beats down all defenses that the normal tissue cells are capable of building up, while in another the attack is less overwhelming and the tissue defense is able to hold the growth in abeyance for a long time. In some patients the defense is feeble, scarcely any fibrous tissue being formed, and the lawless cells proliferate almost at will. In other cases the fibrotic enveloping movement is so prompt and effective that the cancer cells have a very precarious time. It is possible that, under favorable conditions, they may be smothered and a cure of the carcinoma may take place without any one suspecting that it ever existed. At the opening of the battle, there is no means of knowing how forcible is the attack or how adequate the defense; therefore an accurate prognosis is impossible.

I want again to emphasize that a local recurrence should not be considered the sounding of the death knell. Several of my patients have been operated on for a first, a second, and even a third recurrence, and are still alive and apparently free from disease up to ten years after the last recurrence. In order to give the patient the best chance, an operation for recurrence must be carried out along the same lines and with the same boldness as the original operation. Every operation for recurrence, as well as every primary operation, is followed by intensive roentgen-ray treatment.

## ADVANTAGES OF EARLY OPERATION

The clinical picture of breast cancer presented in textbooks needs to be revamped. Even now conscientious physicians who have patients come to them with a lump in the breast calmly wait to see whether malignant symptoms will develop. When one can make a positive preoperative diagnosis of cancer, it is too late for the best average results. The ideal operation for mammary carcinoma is the one that starts in as an exploratory incision. The frozen section made at once by a competent pathologist, together with an intelligent macroscopic examination of the growth after it has been removed, is coming to be the chief method of making the diagnosis.

The praiseworthy efforts to educate the general public and, incidentally, the medical profession as a whole, about the early symptoms of cancer, are bearing fruit, thus far sparingly; but the wonderful possibilities when this propaganda is really carried across make one look forward to the time when the cancer problem will be solved, or at least will cease to be the awful thing it now is.

If any woman could be kept under sufficiently close observation she could be assured against death from cancer of the breast. I should like

to see tried the experiment of keeping 1,000 women under the observation of a trained clinician for a series of years, in order to see whether the above statement cannot be made good. And, if proved true, why could it not be extended to 100,000 women or to all the women of cancer age in the United States? It could be applied equally well to cancer of the uterus, and of the lip, and, in a less positive degree, to cancer of the internal organs.

This idealistic machine is not yet in working form. For the present we can act only when cases come to our attention. A lump in the breast should be looked upon as an emergency surgical condition. In most of these cases it is impossible to say positively that the growth is benign. If cancer is already present, the cell division, the infiltration of tissue, the growth along the lymphatics cannot be expected to mark time, while a slow-thinking and slow-acting physician is looking wise and waiting for symptoms to develop that will permit him to make a positive diagnosis.

#### ORIGIN OF MAMMARY CARCINOMAS

All pathologists are agreed that many mammary carcinomas originate in chronic cystic mastitis; but there seems some question as to whether they originate in adenomas. MacCallum in his "Textbook of Pathology" says: "In such cases it seems necessary to conclude that the carcinoma has developed from an adenoma, but there is no more difficulty in this assumption than in the more usual one that it develops from the normal epithelium of the gland." The favorite site of adenoma is in the upper outer quadrant. Forty-four per cent. of the carcinomas appear in the upper outer quadrant. Most adenomas cause enough neighborhood irritation to produce a surrounding zone of chronic mastitis. It seems safe to conclude that the most usual precancerous lesions recognizable in the breast are benign tumors and chronic cystic mastitis. Therefore, the removal of all benign breast tumors, and the amputation of breasts that are the seat of chronic cystic mastitis, will prevent the development of carcinoma. How great a number of cancers could be prevented by systematically following this plan is not known, but it would no doubt reduce the incidence of breast cancer by a considerable percentage.

#### PATHS OF DISSEMINATION

Before one should be considered qualified to operate for breast cancer, he should have a good understanding of the paths by which it disseminates. The antiquated procedure of slashing off the breast and ineffectively clearing the axilla of fat and glands is fast being relegated to history.

Extension in breast cancer, except the very local infiltration of adjacent tissue, is chiefly through the lymphatics, and metastases through the blood vessels play a minor rôle, usually occurring after all hope of a successful operation is past. Ewing in "Neoplastic Diseases" states that in mammary carcinoma the part played by the blood vessels is distinctly less than that of the lymphatics. We are indebted to Handley for pointing out clearly the rôle of the lymphatics in the dissemination of cancer. Pathologists and clinicians alike are more and more accepting his ideas.

Following the line of reasoning laid down by Handley, if the chief route of dissemination is embolic, through the blood stream, we would expect the locations of metastasis to be similar to the locations of embolic infections, such as are seen in pyemia. This is far from the fact. In pyemia the frequency of splenic and of hepatic abscess is as two to three; in breast cancer the frequency of splenic and of hepatic secondary involvement is as one to fourteen. Again the distribution of secondary deposits is very different in cancer of the uterus, stomach and breast, but it always varies according to the location of the primary growth. In cancer the extension seems to radiate in all directions, but most rapidly in the direction in which the lymphatic supply is richest.

For a long time it was supposed that extension along the lymphatics was accomplished by the cells being swept along the lymph current; but it has been found that the growth extends almost as freely against the current as with it. This bears out Handley's contention that the cancer cells grow along the lymphatic channels by direct growth or permeation. Conceding the general correctness of extension by permeation, it is important to study how the dissemination occurs from a primary nodule located in the breast.

The most important lymphatic highway leads from the breast to the axillary glands. This is especially true in the upper outer quadrant, in which almost one half of all breast cancers originate. Invasion of the axillary glands is usually the first point of attack outside the breast and the pectoral fascia, and they are involved in most cases sooner or later. Occasionally, however, the lungs, the liver and other organs are invaded first, and, in rare instances, the patient may die without the axillary glands having been involved.

Underneath the median hemisphere of the breast is a chain of lymphatics leading to the subclavian glands. These glands should never be overlooked.

The cancer cells may reach the mediastinum, the lungs or the pleura, by growing along the lymphatics that accompany the perforating branches of the internal mammary artery. Averaging the statistics of

several observers, as quoted by Ewing, about 50 per cent. of late cancer cases show invasion of the thoracic cavity.

It is not infrequent for the cells to grow along the lymphatics to the front of the sternum, and to pass along the anastomosing branches, reaching the opposite breast or opposite axillary glands. In my own series, I have records of eight patients that returned later with cancer of the opposite breast. Handley finds the invasion of the opposite breast in 7 per cent. of his cases, and Williams observed it at necropsy in ten of forty-four cases.

Another favorite route of extension is downward to the epigastric angle where the abdominal wall is penetrated, and invasion of the peritoneal cavity begun. It is only an inch, on the average, from the lower lobule of the breast to the epigastric angle. The fascial linea alba is very easily invaded by cancer cells. They pass through to the falciform ligament, fastening themselves on the upper convex surface of the liver; or some of them may pass down by gravity to the lower abdominal cavity, invading the ovaries or uterus. In 2,534 cases of breast cancer reported by a number of hospitals, invasion was found in the liver in 928, or 36.6 per cent.

#### OPERATION

Having a clear idea of the lines along which cancer is disseminated, a definite form of operation calculated to cut off all these highways of dissemination, as far away as possible from the primary growth, appeals to one as the natural procedure. If all the radiating lymphatic trunks can be blocked off, well outside the zone of actual invasion, and all the cancer-bearing tissue within this blocked out area removed, there seems a high degree of probability that the disease will be completely removed.

Before beginning a description of the operation, I wish to speak of a danger that is constantly present in work of this kind. Many local recurrences are unquestionably due to accidental implantation of cancer cells during the progress of the operation. If, inadvertently, the knife enters tissue that looks the least suspicious, the knife and other instruments that might possibly have been soiled, and the gloves worn by operator and assistants, should be pronounced unclean and discarded for new. The suspicious tissue should be swabbed with phenol, and a new and more remote periphery selected. In most cases it is possible to maintain the dissection so far, radially, from the primary lesion that no tissue is entered that looks or feels malignant. It is usually only in advanced cases that any trouble should be encountered.

A routine skin incision is never made. It should be planned according to the location of the growth. A circular or wide elliptical incision is first carried around the primary growth. The margin of this incision should be 2 or 3 inches removed from the infiltrated area. The skin

incision at the upper and outer part should extend from the upper arm at the insertion of the pectoralis and, sweeping inward and downward in a curve just above the axilla, should meet the circular incision at the most advantageous point. The lower leg of the skin incision should extend from the lower margin of the first circular incision, downward and inward to a point 2 or 3 inches below the ensiform over the linea alba.

The old idea that a vast area of skin should be removed had its origin in the mistaken opinion that the cancer extended mainly along the skin. It is now known that the chief mode of extension is along the fascial planes and that the skin involvement means the growing up through the lymphatics from the fascia to the skin. This knowledge has effected a great change in the operation. All skin that seems the least suspicious is removed, but the main object of the operation is to get rid of the lymphatic-bearing fascia over an extensive area, and for a long distance from the primary neoplasm.

The skin is peeled away over this very extensive area first; then the fascia is circumscribed all around by cutting vertically through it at the periphery. This marks out the tissue that it is proposed to remove. The fascia is then rolled inward from the periphery toward the common center. To work from the breast toward the axilla would make it possible to squeeze and push cells growing in the lymphatics toward the axilla, and it would be possible to drive cancer cells from axillary glands into supraclavicular glands. In the same manner, by working downward toward the epigastric angle, cells might be driven into the upper abdomen, gaining lodgment on the liver. Or, by working toward the sternum, cells might be carried into the anterior mediastinum, or even across the anterior surface of the sternum, through the collateral lymphatics into the lymphatics of the opposite side, infecting the opposite breast and axilla. The aim of the operation is to remove all malignant foci, and to do it without risking mechanical extension through ill-advised handling.

Having raised the skin flaps as widely as seems necessary, the attack begins at the axilla. The tendon of the pectoralis major is severed at its attachment, and the muscle is rolled inward, being at the same time separated from the clavicle. After the pectoralis minor is laid bare, this muscle is completely removed. It is never cut and later sutured, as has sometimes been advised. Next, by dividing the costocoracoid membrane just below the clavicle, good access is gained to the axillary space. By care it is easy to get a line of cleavage above the axillary glands and fat, at the superior boundary of the axilla. Gradually the axillary content is worked down by sharp dissection, preferably seeing what is cut and catching any bleeding vessels as the dis-



section proceeds. The dissection should then be carried inward below the clavicle, carefully separating the fat and glands below from the subclavian artery and vein above. By this free exposure, it is easy to see what is done and to make the dissection clean, without risk of damaging vessels or nerves. It is highly important that all the subclavian glands be removed. They are especially liable to be invaded early if the primary neoplasm is located in the inner hemisphere of the breast.

Going back to the axilla, the dissection is carried downward along the lateral surface of the thorax, laying bare the latissimus dorsi and serratus magnus, and dissecting these muscles bare of all glands and fat. I think it is well to sacrifice several of the upper digitations of the serratus magnus as they grow well under the breast and might be involved. They may be removed quite freely, without noticeable impairment of function. If the primary growth is small and localized at the inner segment of the breast, their removal is less imperative than if the growth is advanced, or located in the outer hemisphere.

Passing now to the epigastric angle, the fascia covering the rectus and external oblique is peeled up from below, marking the lowest part of the dissection. This blocks the highway toward the abdomen.

Internally, the skin flap having been raised well toward the midline of the sternum, the fascia is peeled away from within outward, by a clean dissection from the sternum, the costal cartilages and the ribs. This shuts off communication with the opposite breast and the thoracic cavity.

As soon as the entire periphery of the tract to be removed has been raised, it is easy to remove the remainder. By a few strokes of the knife, the entire area marked off can be removed from the chest wall. This is done as cleanly and neatly as possible. Nothing impairs the appearance of this operation so much as to leave tufts of muscle standing out over the thoracic wall; but such an appearance is of minor importance as compared with the possibility of leaving some cell groups which would defeat the object of the operation, or devitalized tissue which may complicate smooth healing.

Hot packs are then placed over the entire denuded area to aid hemostasis. All bleeding vessels have been caught in forceps as the dissection proceeded and now they are methodically tied with fine plain catgut. A stab wound is made through the external skin flap a little below the axilla, and through this is drawn, from within outward, a small rubber drainage tube which is removed in twenty-four hours.

The skin has been undercut over so great an area that its borders are easily approximated without tension. Three to six silkworm-gut sutures are used to bring the skin edges into contact, and a running, interlocked suture of horse hair will quickly and neatly approximate the edges of this long incision.

## POSTOPERATIVE TREATMENT

A copious sterile gauze dressing is put on, and bound on with a jacket. The arm is kept well abducted from the thorax and the elbow rests easily on a pillow. The patient is encouraged to use the arm from the first. No trouble about arm motion has been experienced since it has been kept well away from the side. The second morning after the operation, the patient is propped up in bed, if there is no contra-indication, and after the third or fourth day, she spends a part of each day in an easy chair.

Intensive roentgen-ray treatment is made use of after every radical operation for breast cancer. Everything seems to indicate that this treatment increases the prospects of permanent relief. It doubtless destroys some cells that might otherwise cause trouble.

## INOPERABLE CASES

In spite of all the propaganda, occasional cases are encountered in which it is better not to operate. Among these may be mentioned: (a) deep involvement of the chest wall; (b) firm fixation of the tissues to the chest wall; (c) fixation of the axillary mass; (d) very extensive skin involvement; (e) enlarged and fixed supraclavicular glands; (f) secondary growths in the lungs, liver or other viscera; (g) bone metastasis.

## PROGNOSIS

In the main it seems to me there is a growing optimistic trend in our attitude toward carcinoma of the breast. Even if nothing more is discovered in regard to cancer, the facts now known give an opportunity greatly to lessen the death rate. We have much to hope for from a changed attitude of the public and the rank and file of the profession. The time is coming when late operations will be very rare; when women will be eager for operation on the first discovery of a lump in the breast; when the entire profession will cooperate in getting these unfortunate women to the operating table early; and when surgeons will all be performing radical and efficient operations. It does not seem too optimistic to harbor the hope that a time is coming when 70 or 80 per cent. of these patients may be permanently relieved.

1200 First National Bank Building.

## OBSERVATIONS BASED ON A STUDY OF INJURIES TO THE ELBOW\*

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NEW ORLEANS

At the present time, a lively interest is being manifested in the subject of fractures. This interest is due to several factors, among which may be mentioned the general dissatisfaction which has resulted from the indifferent measures adopted by many surgeons and the indifferent results which have caused economic loss. The desire for improvement is being aided by laws which are demanding an early restoration of function and efficiency. There is a demand for standardization of method and for better results. The American Surgical Association has been instrumental in getting information relative to disability periods, results and similar questions. Prior to their investigation, many surgeons had a sense of self-sufficiency. Following a study of the results in various clinics, individual surgeons are inclined to be more modest, and are therefore showing the interest which they should in newer methods.

Fractures are still being treated by men who have large surgical experience, but who devote little time to the study of this particular field. Fractures are also often treated by men of little experience and training. Fractures are often regarded as a department of minor surgery, which is wrong. How can fractures any longer be considered minor surgery, when such important factors as "carrying angle," limitation of motion at the wrist, coxa vara and loss of weight bearing are dependent on the result of treatment?

Progress results from applying the lessons of personal experience and information gained through a knowledge of the literature of the past and the present. In this way alone can the patient obtain the best result. Errors creep in inadvertently, errors of omission and commission, lack of proper examination, proper history and treatment.

The most common source of error in diagnosis of fracture lies in ignorance of the essentials necessary to make a diagnosis. If not ignorance, let us call it lack of appreciation of fundamentals which should be utilized. For such men, education should be substituted for censure.

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\*Owing to lack of space many illustrations were omitted.

Lack of careful examination and hurried work represent another source of error. Such work demands censure of the individuals as well as education.

Those who, as a result of careful histories, interpret the disability from an anatomic basis, and who also bring to their aid for the benefit of the patient the roentgen ray both before and after treatment, arrive most often at a correct diagnosis. To treat fractures satisfactorily, one must be ever mindful of the relative strength of various portions of bone as well as the comparative strength of bone and ligaments when subjected to strain.

It may seem bold to state that eventually we may hope that diagnosis will often be correctly arrived at by a properly taken history and an analysis of the localization of pain and the associated functional dis-

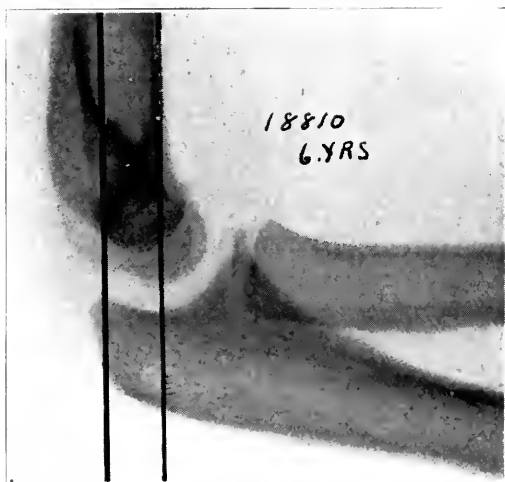


Fig. 1.—Normal relationship of capitellum and great sigmoid cavity. The capitellum occupies the cavity but is not overlapped by the olecranon. The relationship of the lower epiphysis to the bisecting plane of the long axis of the humerus is shown. In early life a plane bisecting the shaft of the humerus passes behind the posterior limit of the capitellum. The plane bisecting the humerus after the ninth year has approximately two thirds of the lower epiphysis in front of it. The plane passed through the anterior limit of the shaft of the humerus has at least one half of the capitellum anterior to it.

ability. When we consider this statement a little more closely, the importance of the truth will be appreciated. Ordinarily, each muscle origin represents the fixed point from which contraction acting on the point of insertion causes the properly coordinated movement. Now, if the bone happens to be fractured between the origin and the insertion of a given group of muscles, this group is rendered inactive.

A lack of harmony results from exaggeration of the action of the opposing group.

Not only is this important in diagnosis; in treatment it is essential to remember it. Otherwise reduction will fail more often than it will succeed.

Any plea for improvement in fracture results must be based not on a preconceived system but on a clearer knowledge and attention to fundamentals.

This report is made because I should like to emphasize the value of fundamental knowledge which should be more widespread and

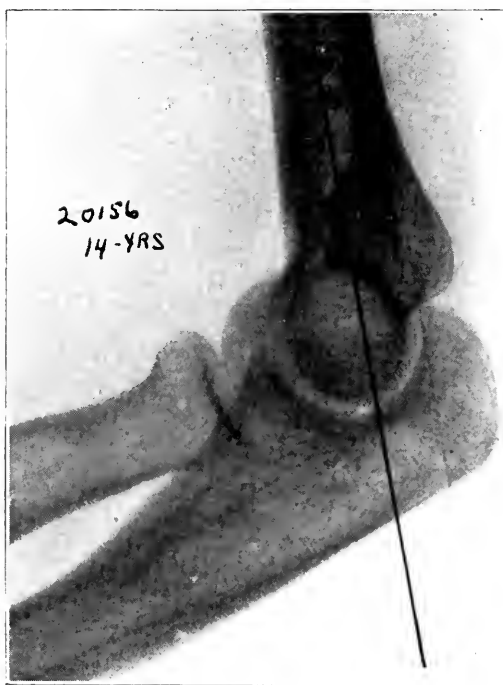


Fig. 2.—Normal relationship of capitellum and great sigmoid cavity. The capitellum occupies the cavity but is overlapped by the olecranon. The relationship of the lower epiphysis to the bisecting plane of the long axis of the humerus is shown. In early life a plane bisecting the shaft of the humerus passes behind the posterior limit of the capitellum. The plane bisecting the humerus after the ninth year has approximately two thirds of the lower epiphysis in front of it. The plane passed through the anterior limit of the shaft of the humerus has at least one half of the capitellum anterior to it.

the usefulness of which, even among those who should know, we find has not been fully realized. I refer to the roentgen-ray examination particularly of joints and joint fractures in the young. The appearance of the normal epiphysis at varying ages has proved one of the most

fascinating studies I have ever attempted. In another contribution, devoted entirely to the appearance of the normal elbow at all ages up to and including 17 years of age, many interesting facts have been stated.

In the past, we have been impressed by the number of roentgen-ray reports suggesting seriously disturbed elbows, which on clinical examination presented no abnormality, and also by a few cases which suggested a fracture in which the roentgenogram failed to be of service to us. Another type of report which proved puzzling was the number of reported epiphyseal separations.

An analysis of the reported fractures in clinically normal joints can be easily understood after one has made a study of normal joints. The answer is simply that epiphyseal lines were mistaken for fracture lines.

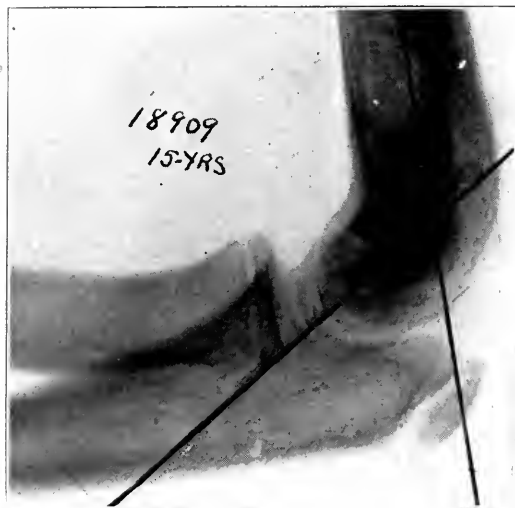


Fig. 3.—A plane at right angles to the base of the capitulum and bisecting it intersects the plane through the middle of the long axis of the shaft at an angle of about 130 degrees (author's lines).

How can we interpret the other two reports? Let us take those in which clinically there is an intra-articular fracture and the report is negative.

We know very well that up to a certain age certain epiphyses are not apparent in the roentgen-ray examination and hence an injury to these will not show on the plate.

It is very easy to see why epiphyseal separations have been reported, because there has not been an available standard for comparison, and further there has not been a general appreciation of the fact that the epiphyses bear a relatively constant position to the shaft.

A diagnosis of epiphyseal separation can be made roentgenographically only by a gross alteration of the normal relationship of the

epiphyses to the shaft, and by certain lines which are here described. If any one has described these lines before, they have not been called to my attention, nor have I seen mention of them in the literature. I believe that, with a clear knowledge of the normal appearance of the elbow, and the relationship of the articular portion of the humerus and the ulna, we can eliminate many errors in diagnosis; and, furthermore, one can definitely state from the roentgenogram that there is an existing deformity. If these things are possible, certainly they need more general adoption, because thereby a source of error will have been corrected.

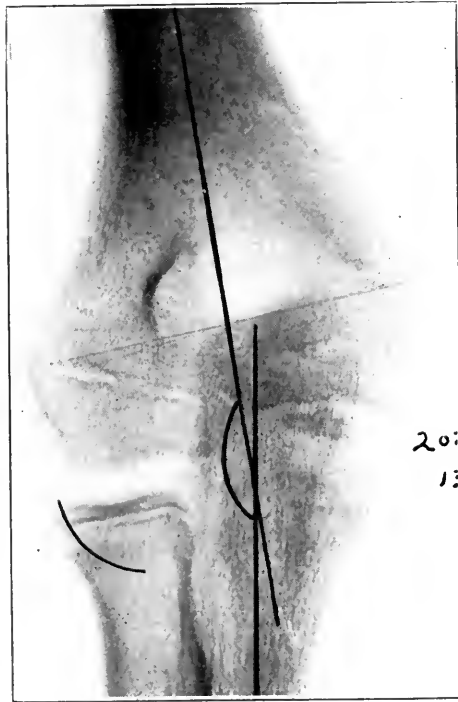


Fig. 4.—With forearm extended and supinated, a plane through the middle of the long axis of the humerus is intersected by a plane through the middle of the long axis of the ulna at an angle of approximately 170 degrees.

The position of the capitellum is most important.

With the elbow flexed to a right angle, a lateral view of the elbow shows the capitellum occupying the sigmoid cavity. In early life, there seems to be a wide separation between the articular surface of the capitellum and the great sigmoid cavity, but with growth the capitellum occupies the entire cavity and is closely approximated to the sigmoid cavity (Figs. 1 and 2).

A plane passed through the middle of the long axis of the shaft of the humerus prior to about the ninth year passes behind the posterior border of the capitellum; after this period the plane bisecting the shaft of the humerus has approximately two thirds of the lower epiphyses anterior to it (Figs. 1 and 2).

The plane of the anterior limit of the shaft of the humerus shows at least one half of the capitellum anterior to it (Fig. 4 and Fig. 1).

A plane at right angles to the base of the capitellum and bisecting it intersects the plane through the middle of the long axis of the shaft at an angle of about 130 degrees (Fig. 3).



Fig. 5.—The normal position of the olecranon, occupying the entire olecranon fossa.

When the forearm is extended on the arm and supinated, a plane passed through the middle of the long axis of the humerus is intersected by a plane through the middle of the long axis of the ulna at an angle of approximately 170 degrees (Fig. 4).

The olecranon occupies the entire olecranon fossa (Fig. 5).

An attempt will be made to show by an illustrative case the value of a knowledge of the exact appearance of normal joints, in order to state definitely from the picture that an epiphyseal separation exists.

CASE 1.—W. B., (20,835), aged 13 years, while playing fell backward and struck his right elbow against a brick curb. He suffered considerable pain.



Examination at the clinic, by Dr. I. M. Gage, revealed considerable swelling over the internal condyle, with pain on palpation. Crepitus was elicited on movement of the elbow. The roentgenogram (Fig. 6*B*) shows the epiphysis of the internal epicondyle widely separated from the shaft and on a much lower level than the internal oblique line of the shaft. The elbow was flexed and bandaged in the usual hyperflexed position. A picture in this position shows a restoration of the normal position of the internal epicondyle to the shaft (Fig. 6*A*).

To illustrate the point that roentgenograms fail us in diagnosis of intra-articular fractures, the following case may be cited briefly.

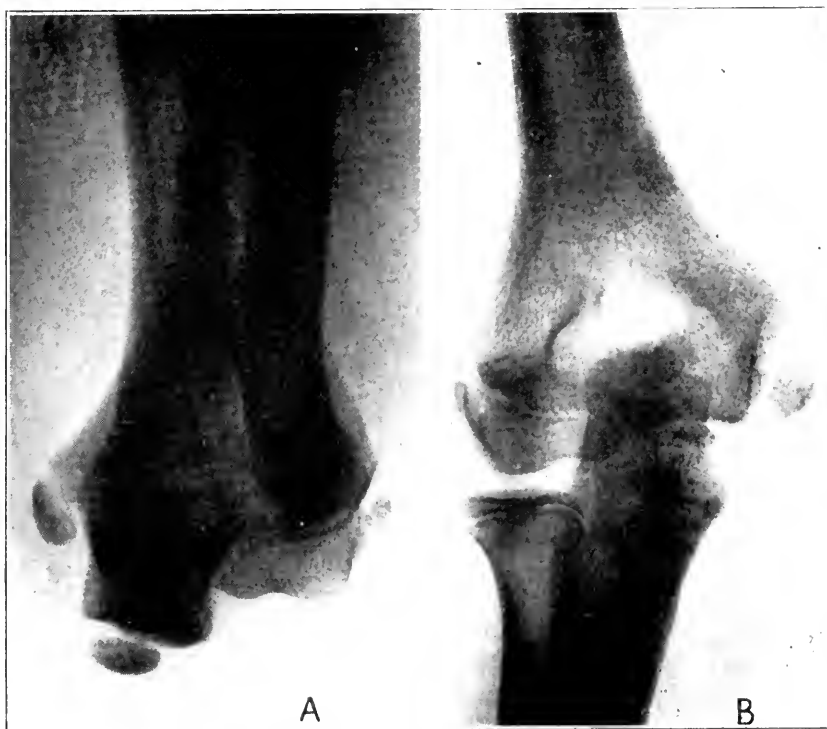


Fig. 6.—*A*, normal position of the internal epicondyle; *B*, position of the internal epicondyle in case of epiphyseal separation, showing the wide separation and illustrating the fact that the epicondyle is on a lower level than the internal oblique line when separated (Case 1).

CASE 2.—C. S., boy, aged 8 years, presented the typical deformity of a backward dislocation of the elbow. This is all that was demonstrated by the roentgenogram. Under anesthesia the reduction was easily accomplished, but we were then able to palpate a loose body in the region of the internal epicondyle. The subsequent course was uneventful.

The value of the lines which have been described may best be illustrated by the presentation of a few cases in which the results were not good.

When vicious union has resulted and when the patient presents a cubitus varus, the capitellum does not occupy the sigmoid cavity, but is on a lower level and its shadow is overlapped by that of the olecranon in part (Figs. 7 *A*, 8 *A* and 9 *A*). When a perfect result has been obtained, it is found that the articular surface of the humerus lies in its normal bed.

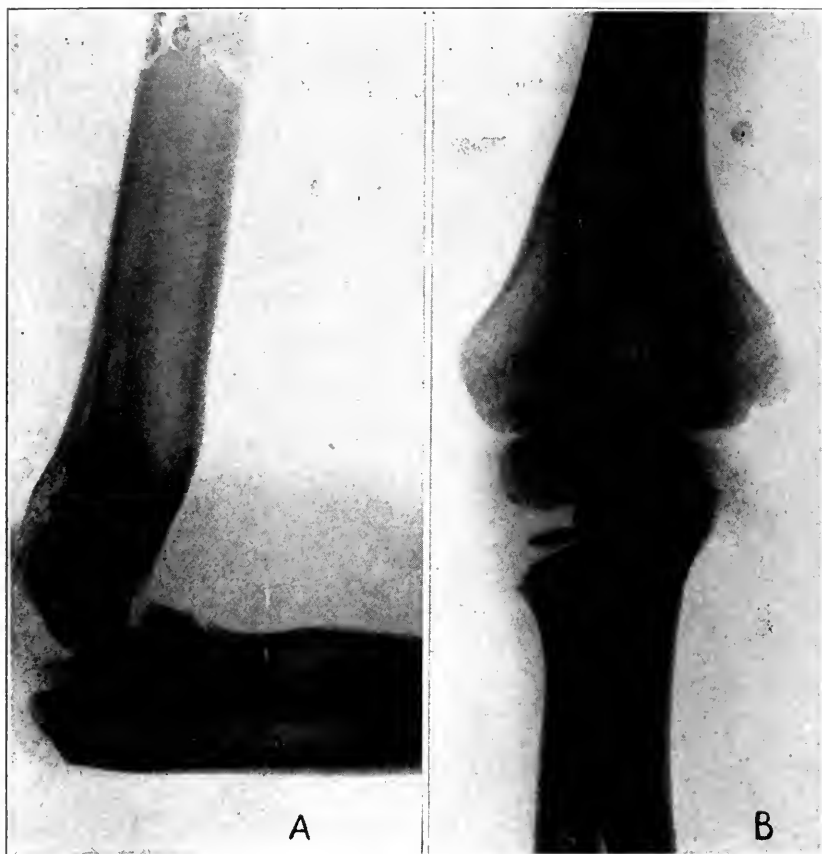


Fig. 7.—*A*, altered position of capitellum when vicious union has resulted, showing overlapping of the capitellum by the olecranon shadow rather than the normal appearance of the capitellum occupying the cavity: *B*, when compared with the normal elbow (Fig. 4), it will be readily seen that the plane through the long axis of the humerus is practically the same plane as the one bisecting the shaft of the ulna, illustrating the value of the lines described in Figure 4.

This report represents an analysis of a group of unselected cases from our clinic and from my private records. An attempt will be made to make the review as impartial as possible.

Several points are apparent.

Many case histories have been incomplete and a considerable number give evidence of hastily taken records of examination. Many reported cases of epiphyseal separation have been received, which are manifestly normal joints in the light of our recent study. Many cases have been referred to the roentgenologist for examination, and negative reports received from that department.

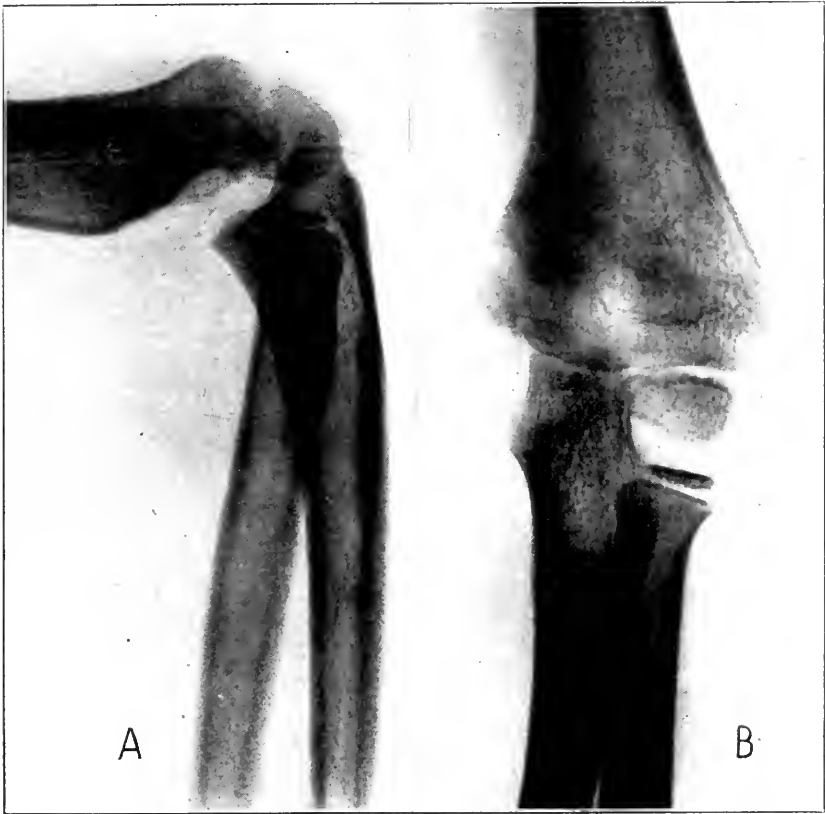


Fig. 8.—*A*, altered position of the capitellum when vicious union has resulted, showing overlapping of the capitellum by the olecranon shadow rather than the normal appearance of the capitellum occupying the cavity: *B*, when compared with the normal elbow (Fig. 4), it will be readily seen that the plane through the long axis of the humerus is practically the same plane as the one bisecting the shaft of the ulna, illustrating the value of the lines described in Figure 4.

These two sources of error suggest three things which are necessary in the treatment of fractures: a clear knowledge of the normal on the part of the roentgenologist; a more careful examination of the patient, to eliminate unnecessary work, and, last, a closer cooperation between the roentgenologist and surgeon which will prove helpful to all.

A suggestion from the roentgenologist that, as a result of his study of the picture, he would make a prognosis of a deformity if the fracture is allowed to remain in the position that it was in when the patient was sent to him, will prevent many future disabilities and deformities.

#### DIVISION OF CASES

We may divide the cases of elbow injuries into those in which examinations, clinical and radiologic, have been negative; cases in

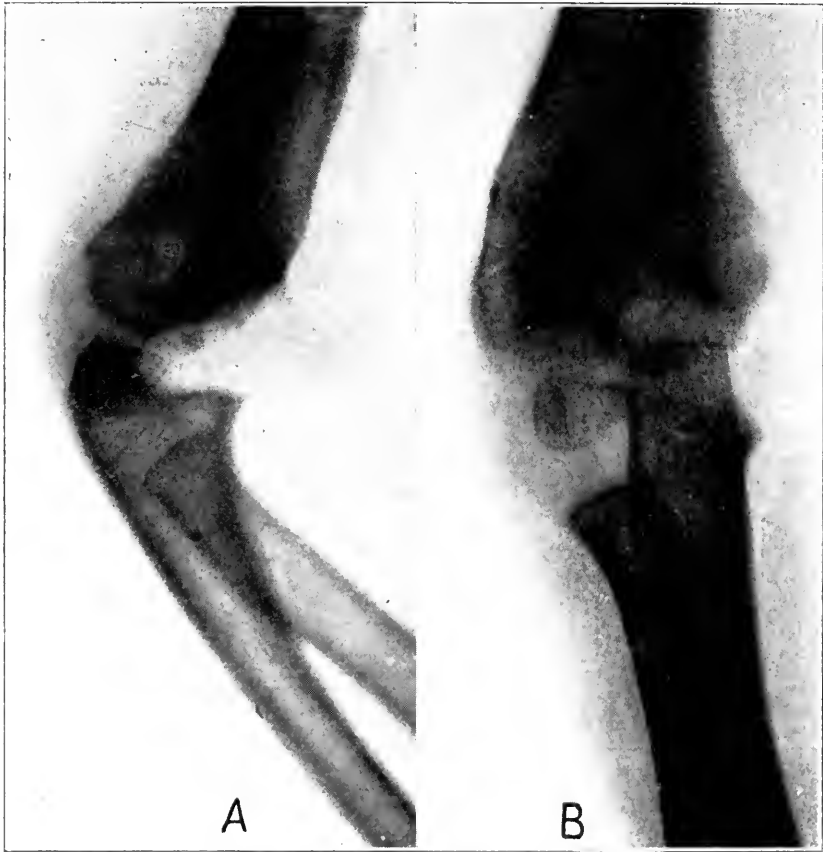


Fig. 9.—*A*, altered position of the capitellum when vicious union has resulted, showing overlapping of the capitellum by the olecranon shadow rather than the normal appearance of the capitellum occupying the cavity; *B*, when compared with the normal elbow (Fig. 4), it will be readily seen that the plane through the long axis of the humerus is practically the same plane as the one bisecting the shaft of the ulna, illustrating the value of the lines described in Figure 4.

which there has been a separation of the epiphyses, and cases in which there has been a fracture. The fracture cases then subdivide them-

selves into two classes ; those which come under observation immediately and those which are not seen for several hours.

In an attempt to follow up cases, about seventy-five patients were written to, with a request that they present themselves for examination. From those who returned we have obtained the material for this study. The information thus obtained has enabled us to note whether there was a perfect functional result or how much disability existed, and to



Fig. 10 (Case 7).—Results in a case of supracondylar fracture which came under observation late.

gather information relative to the roentgen-ray appearance of the fractured bone.

A small group of patients with deformity and disability presented themselves for examination. These cases, while the condition is humiliating, give more real beneficial information than the larger group with good results. It was from the small group which presented disability and deformity that we were made to realize the value of the roentgen ray in making a prognosis.

In every case in which we found an existing deformity, several things became apparent when the history was referred to. In brief, the facts are these: The patient usually presented himself for treatment several hours after the injury, during which time swelling had appeared, making it impossible to maintain the hyperflexed position.

Citation of two cases, with remarks, will serve to prove my point.



Fig. 11 (Case 7).—Results in a case of supracondylar fracture which came under observation late.

CASE 3 (16,790).—I. C., negro boy, aged 4 years, fell from a wagon two days before examination, March 12, 1918.

*Examination.*—The arm hung by his side. There was marked cubitus varus, swelling about the elbow, pain over both condyles, and loss of flexion and extension.

*Treatment.*—Under anesthesia, the impaction was broken up, but we were unable to put the elbow in hyperflexion, as this position caused an obliteration of

the radial pulse. Anterior and posterior plaster splints were applied; the right angle position being used. The roentgen-ray report prior to the dressing was: Supracondyloid fracture, backward displacement of the lower fragment.

*Subsequent Course.*—In following up this case, we found, one year later, that there was a loss of the carrying angle, cubitus varus and limitation of flexion and extension.

April 14, 1919: A cuneiform osteotomy was performed.

Oct. 30, 1920: Examination revealed perfect flexion and extension of the elbow; no limitation of pronation and supination, and a slightly diminished carrying angle.

CASE 4.—G. M. (17.222), June 13, 1918, had fallen from a porch the day before; had been treated in the emergency clinic at Touro infirmary at once with a diagnosis of supracondyloid fracture. No anesthetic was given. The dressing did not include the hand. When I saw the child, the hand and forearm were very much swollen. The hand of the injured arm was much colder than the opposite hand.

*Treatment.*—Under ether anesthesia, an attempt was made to reduce the deformity. It was impossible to utilize the position of hyperflexion, because of



Fig. 12 (Case 7).—Results in a case of supracondyloid fracture which came under observation late.

obliteration of the radial pulse; therefore anterior and posterior molded plaster splints were used.

*Subsequent Course.*—Examination, April 22, 1919, revealed a loss of carrying angle, and slight cubitus varus. The forearm could be flexed to the normal limit and extended completely.

At examination, Nov. 11, 1920, the same notes were made as at the previous examination. The roentgenogram taken, Nov. 11, 1920, revealed: a vicious union of an old fracture of the humerus. The lower portion was united to the shaft in a plane oblique to that of the long axis of the shaft.

The capitellum was overlapped by the shadow of the olecranon and sigmoid cavity, rather than occupying the cavity.

A plane passed through the anterior aspect of the long axis of the humerus passed anterior to the plane of the capitellum, showing that the capitellum was displaced backward.

The plane passed through the middle of the long axis of the shaft was anterior to the capitellum, instead of the capitellum's being either entirely in front of this plane or two thirds of its body anterior to this plane (Figs. 7A and 7B).

CASE 5 (61,920).—L. S., boy, aged 7 years, came under observation in the clinic, May 31, 1919, the day following the accident. Examination made by Dr. P. G. Lacroix revealed: swelling of the forearm, cubitus varus, and pain over the lower end of the humerus. No record was made of the after-care in this case. The child reported to the clinic at my request for examination. I found: marked cubitus varus—slight limitation of flexion; no loss of the normal range of extension, and no limitation of pronation and supination. The roentgenogram in this case presented the same important findings as were noted in the previous case (Figs. 8 *A* and 8 *B*).

CASE 6.—M. S., about five weeks before fell on her outstretched hand. When seen by her local physician, he told the parents that there was so much swelling that he could do nothing for her. Aug. 28, 1920, I examined her and



Fig. 13.—Comminuted fracture of the humerus, in which case a fracture of the olecranon was also reported. The apparent fracture is an unossified olecranon epiphysis.

found marked cubitus varus with internal rotation of the arm. There was limitation of flexion and extension of the elbow.

*Diagnosis.*—Vicious union, supracondyloid fracture of the humerus was diagnosed (Figs. 9 *A* and 9 *B*).

*Operation.*—Under ether anesthesia (Dr. Rives, anesthetist), an external lateral incision was made, beginning about the middle third of the arm, and extending down to about the level of the head of the radius. The brachialis anticus muscle was retracted inward, the radial nerve was exposed and retracted inward, as well as the supinator longus muscle. The periosteum was incised and retracted. The brachialis anticus was retracted from the humerus, and an anterior cuneiform osteotomy was performed. The divided ends of the humerus were drilled, and a kangaroo tendon suture was introduced, merely



for temporary fixation. When the elbow was extended, I noticed that the carrying angle had been restored, and complete flexion of the elbow was now possible. A few interrupted sutures were introduced and the arm placed in hyperflexion. The wound healed by primary intention.

*Subsequent Course.*—The patient left the hospital, Sept. 7, 1920, at which time she could extend the elbow well beyond a right angle.

At the time the last note was made on this case, Oct. 30, 1920, the patient could completely extend the elbow. She carried the arm in a position of internal rotation, and pronation of the forearm. If the forearm was supinated and held in this position the carrying angle was restored, showing that there was a relaxation of the external lateral ligament, and that the internal rotators were more active than the external rotators. Roentgenograms (Figs. 9 *A* and 9 *B*) showed the same points as the preceding pictures; overlapping of capitellum by olecranon shadow and backward displacement of capitellum.

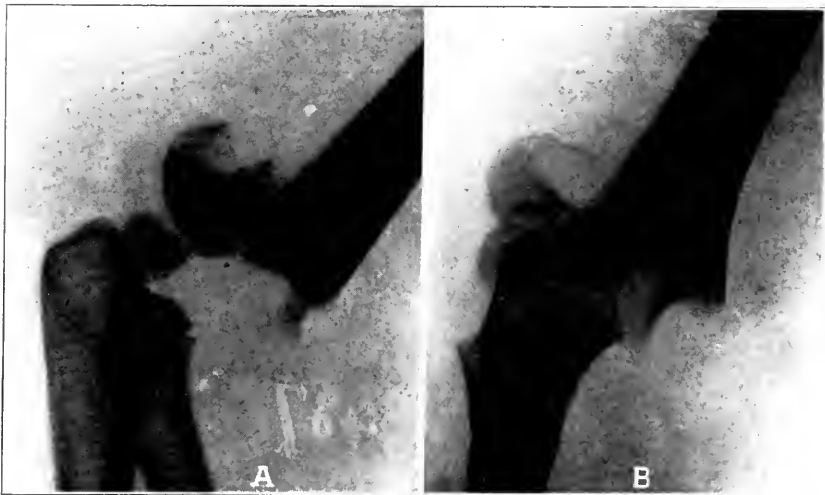


Fig. 14 (Case 10).—Appearance of elbow before attempts at reduction.

#### COMMENT

The case of M. S. showed such a marked deformity that an effort was made to overcome it by operation. Before undertaking the operation, the case was studied in the light of our normal pictures. It is easy to understand the limitation of extension as we will note the obliquity backward of the distal end of the humerus in this and other cases with similar deformities. The olecranon meets an obstruction before extension is accomplished, and it no longer can reach the olecranon fossa, but is stopped by the lower end of the humerus. Flexion is impossible because the coronoid probably strikes against the lower end of the humerus before it can reach the coronoid fossa. The problem to be solved, therefore, is a reconstruction of the normal axis of the lower fragment, which means that it must be displaced forward. It

seems logical, therefore, that if a cuneiform section of the humerus is removed anteriorly this will then allow the lower fragment to be flexed or molded into position. This brings the capitellum forward, and it will allow the olecranon to reach the olecranon fossa, as shown by the accompanying illustrations.

In order to accomplish this with the least damage to the periarticular structures, one had best follow the suggestions of James Thompson, of Galveston, in his monograph relative to the approach to long bones. Briefly, they may be stated thus: Deep wounds should be avoided, when the shallow ones will suffice. All nerve supply should be preserved. Unnecessary injury to muscle should be avoided, the work being done between muscles rather than their being sectioned. When section is necessary it should be made as far from the nerve supply as possible. The blood supply should be preserved.



Fig. 15 (Case 10).—*A*, appearance of elbow after attempt at reduction, five days after the accident; *B*, final result. There were complete extension and flexion to 45 degrees and perfect pronation and supination.

In approaching the elbow in this case and in similar cases, these principles were adhered to as nearly as possible.

The procedure adopted was briefly this: An external lateral incision was made, beginning about 2 inches above the elbow, and extending down the forearm a like distance. The brachialis anticus was exposed and the radial nerve was seen prior to its passage through the supinator longus. The supinator was retracted to the inner side of the wound. The periosteum was incised and retracted. It is important not to interfere with the epiphyses. This can be done by making the section above the epiphyseal line, and further by operating from before back-

ward with the muscles well retracted forward. There is no danger of injuring any of the important vessels about the elbow.

CASE 7 (16,088).—L. L., aged 6 years, Sept. 11, 1917, was admitted with a supracondyloid fracture of the humerus. She had fallen from a porch. Several hours after the accident she was brought to the hospital. The arm was hanging by the side, abducted at the elbow more than normal. The entire arm was swollen. Under ether anesthesia, a complete supracondyloid fracture was found. Because of the great amount of swelling, it was impossible to maintain hyperflexion. A Jones elbow extension splint was tried, but the one at hand was too large, therefore anterior and posterior plaster splints were applied.



Fig. 16 (Case 11).—Supracondyloid fracture which was misinterpreted as an "epiphyseal" separation.

September 12: The dressing had to be removed because of swelling. A roentgenogram showed T fracture above both condyles with some lateral displacement.

September 20: There was less swelling of the arm and forearm and less pain. The dressing was changed and the degree of extension increased.

September 27: The arm was placed in complete extension, the elbow was manipulated, and hyperflexion of the elbow was obtained.

A roentgenogram revealed old supracondyloid fracture of the humerus and union with deformity.

Dec. 29, 1917: The patient was able to extend the arm to 160 degrees and to flex it to about 45 degrees.

Oct. 30, 1920: The child came to the clinic in answer to my request. Examination at this time revealed complete extension of the elbow and perfect flexion, no limitation of pronation and supination, and a normal carrying angle. The roentgenogram showed a normal elbow, so far as the lines were concerned, but a premature ossification within the epiphyses of the lower end of the humerus (Figs. 10 *A*, 10 *B*, 11 and 12).

CASE 8 (3455).—(Diagnosis: fracture of the external condyle).—*History*.—J. Z., boy, white, aged 9 years, fell from a horse, Feb. 8, 1912. He was seen by Dr. Gessner, February 9, at which time the swelling was so great that he was unable to make use of the hyperflexion position. Instead, however, he put



Fig. 17.—Supracondylar fracture misinterpreted as an "epiphyseal" separation.

the arm at right angles. This position he maintained until February 16, at which time he again tried to hyperflex the elbow, but again the position caused an obliteration of the radial pulse.

*Examination*.—The case was referred to me at the clinic, February 19. Examination at that time revealed a marked deformity, cubitus varus, crepitus over the external condyle, redness and swelling, a small granulating wound over the external condyle.

*Diagnosis*.—Fracture of the external condyle was diagnosed.

*Operation*.—Under anesthesia, the elbow was acutely flexed, the deformity reduced and the parts bandaged as described.

*Subsequent Course.*—He was kept under observation about four weeks, at the end of which time we were trying to obtain some motion in the joint. When last seen, he could flex the arm at an angle of 45 degrees and extend it to an angle of 130 degrees. Letters directed to the father failed to bring the child to the clinic for inspection.

CASE 9.—F. C., boy, white, aged 14, was examined at the clinic April 30, 1912. (The exact data regarding how the accident happened are not recorded). There was evidence of fracture of the lower end of the humerus. The roentgenogram (Fig. 13) demonstrates the exact nature of the injury, there being a



Fig. 18.—Displacement of internal epicondyle in case of separation of this epiphysis.

comminuted fracture of the lower end of the humerus involving both condyles and the olecranon process of the ulna.<sup>1</sup>

The usual treatment was followed, and at the end of four weeks he left the city and I have not seen him since.

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1. At present we know that the ulna was not fractured, but the normal epiphyseal line of the unossified olecranon was interpreted as a fracture.

Dr. Maner of Bay St. Louis, Miss., wrote me a letter some time ago and informed me that the boy was able to row and swim with ease.

*CASE 10.—History.*—L. L., admitted, May 10, 1919, five days before while on board a ship fell and injured his elbow. The physician on board considered the injury "a severe sprain" and did nothing, except put a bandage on.

*Examination.*—When the patient came under observation five days later (May 10) there was marked swelling and backward displacement of the elbow, and the forearm was pronated. The forearm extended almost completely; the carrying angle was lost and the hand was swollen.

*Operation.*—Under ether anesthesia, an attempt was made to reduce the deformity. Hypertflexion could not be maintained because of the great swelling. Right angle plaster molded splints were applied.



Fig. 19 (Case 13).—Normal joint misinterpreted by roentgenologist as "supracondyloid fracture and separation of olecranon process."

*Roentgen-Ray Examination.*—The roentgenograms made before and after this attempt are shown in Figures 14 *A*, 14 *B* and 15 *A*. Subsequent attempts to reduce the deformity had to be made after the swelling had subsided. The final roentgenogram shows the result.

Dec. 23, 1919: Complete extension was possible and flexion to 45 degrees. Pronation and supination were normal. Roentgen-ray report at this time states: "Perfect union. No evidence of previous fracture except excess of callus on lower anterior aspect of humerus" (Fig. 15 *B*).

#### MISINTERPRETATION OF FRACTURES

As a result of my recent study of normal joints in the young I have been interested to note how valuable the information really is when I consider the cases which have previously been reported as having epiphyseal separations.

Citation of a few cases with illustrations will prove the point. Supracondyloid fractures have in the past been misinterpreted by our roentgenologist as epiphyseal separations.

CASE 11 (17930).—M. V. H., girl, aged 4 years, fell from a small wagon and struck her elbow. Pain in the elbow and loss of function are noted on the history card. Roentgenogram 15379: Epiphyseal separation of lower end of humerus. Position good.

The true interpretation in the light of our present knowledge is that there was in this case a supracondyloid fracture—incomplete in the transverse axis of the humerus (Fig. 16).

Under ether anesthesia, the examination was completed. There was no limitation of extension, the carrying angle was not lost, but slightly diminished. The head of the radius rotated with the shaft of the radius.



Fig. 20 (Case 13).—Result in case of fracture of right internal condyle and fracture of left internal condyle of the humerus.

The same error in roentgen-ray interpretation was made in the case of E. M., aged 5 years; “epiphyseal separation of the lower end of the humerus, some slight dislocation of the condyle” (Fig. 17). These mistakes could not have occurred if we had known that the internal condyle does not appear at the ages of the patients in question, and further that the internal condyle when it is apparent is on a level with the internal oblique line of the shaft of the humerus. Any displacement of the internal epicondyle is evidenced by the alteration in its position. Usually it takes a downward position, with relation to the oblique line as is evidenced by the next illustration, which is that of Case 21,915 (Fig. 18).

CASE 12 (17572).—(Notes taken by Dr. H. B. Gessner).—H. C. presented a suspected fracture of the right elbow. A roentgenogram was requested. The roentgen-ray report was: “epiphyseal separation, lower end of humerus.” The physical findings were negative.

CASE 13 (17,837).—(Figs. 19 *A* and 19 *B*).—W. C., aged 15 years, Nov. 14, 1918, presented an elbow which had been swollen since November 12. There was no history of an injury.

Roentgenogram 15234 revealed: Supracondyloid fracture and separation of the olecranon process of the ulna.

Interpretation at the present time in the light of study of normal joints is that this was a normal joint.

These errors could not have crept in had our roentgenologist known the normal.

#### DEDUCTIONS

The roentgen ray can be of inestimable value when proper interpretation is put on the pictures. This can only be done by having a clear knowledge of the normal. In order to compare the roentgenogram of a particular case, we must compare it with the average normal for that particular age, such a series of roentgenograms as we have utilized, and which has recently been published.<sup>2</sup>



Fig. 21.—(Case 13).—Result in case of fracture of right internal condyle and left internal condyle of the humerus.

A roentgenogram must not be depended on to show a fracture within an epiphysis in young children before the particular epiphysis has sufficiently ossified.

A knowledge of the normal elbow will prevent future errors by making possible the differentiation of normal epiphyses from fractures.

A disturbance of the relationship of certain planes mentioned in this work will enable the roentgenologist to state that there will be disturbance of function and deformity unless the condition is corrected. This particularly applies to the overlapping of the shadow of the capitulum by the olecranon.

In some instances, there is certainty that the deformity has not been reduced, and from my experience I believe that you can prophecy that a cubitus varus will develop.

2. Cohn, Isidore: Observations on the Normally Developing Elbow, *Arch. Surg.* 2:455 (May) 1921.



Delay in reducing the deformity gives opportunity for swelling to take place, after which the difficulty of treatment is increased, particularly with reference to the hyperflexed position.

Attention must be directed toward developing the external rotators of the humerus, otherwise patients who have supracondyloid fractures have a tendency frequently to continue carrying the arm in the position of internal rotation, which will give rise to a cubitus varus, of muscular origin rather than of bony origin.

The following group of cases is presented in contrast to the preceding groups because they represent the results which follow the applica-



Fig. 22 (Case 15).—Functional result in case of supracondyloid fracture of humerus immediately after fracture and three years later.

tion of principles which are not merely ideas, but convictions in regard to elbow injuries.

The history is of inestimable value; in a broad sense, it includes all of the facts relative to, as well as subjective and objective phenomena associated with, the injury. Many have empirically stated in the past that certain injuries are associated with a certain group of signs and symptoms. What is most to be desired is a diagnosis based on a logical interpretation of historical facts and symptoms as well as

clinical manifestations. Every sign and symptom is present because of a definite anatomic change incident to the lesion present. Examination of an injured elbow should be undertaken in a systematic manner, with a full appreciation of what is to be gained by each step.

The most evident phenomenon on inspection is the position—semi-flexion, and diminished or lost carrying angle.

There are many causes for these phenomena. Due attention to each will enable the examiner to reach conclusions which may save the patient much painful manipulation in an attempt to arrive at the final diagnosis. It is not to be understood that it is my belief that inspection will be all that is necessary, but it will be very helpful.

The normal carrying angle is the result of several factors, among which may be mentioned the obliquity of the lower end of the humerus as compared to the shaft of the humerus, and the consequent relative position of the articulation of the ulna with the humerus. Anything which will permit of greater freedom of motion of the ulna in a lateral



Fig. 23 (Case 15).—Functional result.

direction on the humerus will alter the carrying angle. If the above is true, then we must consider the capsule of the elbow as well as the muscular attachments in the vicinity of the condyles.

Turning to our anatomies we find, "The capsular ligament surrounding the joint is very weak behind, stronger in front and very strong at the sides. The sides are commonly called the lateral ligaments. The lateral ligaments radiate from below to the tips of the condyles. The lateral ligaments of the normal joints should always be tense" (Piersol).

From the foregoing, it follows logically that a tear of the lateral ligaments will give rise to an increase in the lateral mobility of the joint. If to the tear of the ligament is added a fracture through one of the condyles, or above the condyles, we will have not only the abnormal lateral mobility, due to the tear, but there will be added

lateral mobility in the direction of the contraction of the group of muscles remaining attached to the shaft, being unopposed by the group torn away from the shaft.

If, therefore, we interpret the exaggerated lateral mobility, as evidence of an injury to the capsule and the contraction of these muscles attached to the shaft, we are in a position then to proceed with further examination, with some knowledge of the probable location of the injury.



Fig. 24 (Case 15).—Functional result.

Palpation always reveals pain at the site of the fracture. If then the two bits of information obtained by inspection and palpation are correlated with anatomic facts, it is reasonable to suppose that it will not be necessary to manipulate a great deal prior to taking a roentgenogram. Manipulation causes pain, and if the patient happens to be a child, as is often the case, the future handling of the case will be more difficult.

The picture must not be accepted as a final statement of the case, if it does not show a condition, belief in the existence of which is justified by examination.

This later statement is based on the fact previously stated that in the young the epiphyses are not evident roentgenographically, and a fracture through one of these does not show.

Under anesthesia, the examination should be continued. Oftentimes the small fragment which was not evident in the picture will be palpated and can be felt to slip back into its normal "bed." Following



Fig. 25 (Case 16).—Result in case of supracondyloid fracture of the humerus.

such manipulation the carrying angle has been seen to be restored, and flexion and extension accomplished within normal range.

Further it is important after reduction to make a roentgenogram to determine whether the relationship of the capitellum to the sigmoid cavity has been restored. As mentioned before, it should lie well within this cavity and should not be overlapped by the shadow of the sigmoid cavity. If such a condition exists, the deformity has not been reduced, and failure to attend to this detail will result in a cubitus varus. The importance of this cannot be overestimated.

Incidentally, it should be borne in mind that a persistence of this deformity may result from two conditions: a relaxed or stretched

capsule, following the accident, and the overactivity of the internal rotators of the humerus (Case 6, Figs. 9 *A* and 9 *B*).

The importance of the integrity of the internal lateral ligaments has been emphasized by Sir Robert Jones, in connection with operation on the knee. The relaxation of the internal lateral ligament at the knee means a weak and wobbly knee. The same is true of the elbow, and the importance of this source of deformity is too little appreciated.

The position of the forearm with reference to the arm is important: to say hyperflexion and stop is not sufficient, because what is the proper position with one fracture is not the correct one for another. Only by reference to muscle attachments and origins can we be certain of the proper attitude. The rule to bear in mind is always to relax the muscles which are tending to increase the deformity by their contraction, and to bring the axis of the fragments over which you have control into the plane of axis of the fragments over which you have no control, thus producing an equilibrium of forces.



Fig. 26 (Case 16).—Result in case of supracondyloid fracture of the humerus.

Applied to the elbow, this can only be stated by naming the muscles attached about the elbow, and showing by diagrams their particular action, when acting harmoniously and their action after an injury.

It is hardly necessary to restate what has often been stated that hyperflexion is the position of greatest stability in supracondyloid fractures, because the triceps act as a natural splint, and there is a relaxation of all of the flexors which have a tendency to bring the distal fragment into the bend of the elbow.

In fractures of the internal condyle, it is desirable to have not only hyperflexion, but also pronation of the forearm.

This is true because contraction of muscles attached to the shaft, particularly the brachioradialis, tends to supinate the forearm; the supinator brevis which arises from the external condyle and orbicular ligament supinates the forearm, and probably by its contraction, fol-

lowing fractures of the internal condyle, which is often associated with a tear of the internal lateral ligament, tends to diminish the carrying angle.

The anconeus, which arises from the external condyle and is inserted into the ulna, aids the triceps in extending the arm, and also probably aids in altering the relative axis of the ulna to the humerus, thus exaggerating the cubitus varus deformity.

The contraction of the pronator teres, which originates from the internal condyle, tends to pronate the forearm and by its contraction pulls the loose fragment away from the shaft. Therefore, in order to maintain a position of stability, one in which there will be the least tendency to reproduction of deformity, hyperflexion and pronation will be found most desirable.

In fractures of the external condyle, the position of greatest stability is one of hyperflexion and supination, for these reasons:

Pronation would allow the pronator teres to pronate the forearm and thus pull the external condyle away from the shaft. In supination

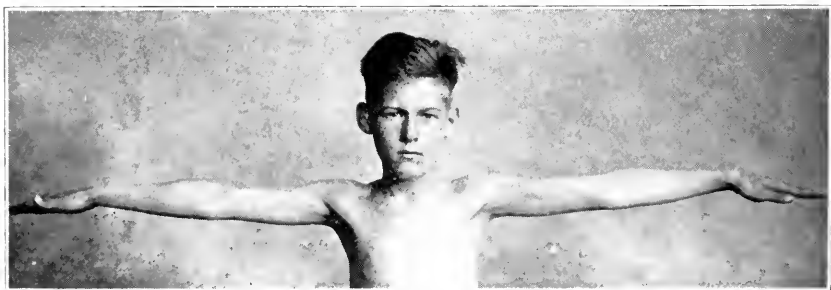


Fig. 27 (Case 17).—Result in case of supracondyloid fracture of the humerus.

the pronator is opposed by the artificial force of the bandage, and contraction of the supinator brings the external condyle into closer contact with the humerus.

Reduction having been accomplished and the proper dressing applied, the difficulty often arises of keeping the bandage from slipping from the elbow. It has been found useful to have a conical bag made, the apex down. In such a bag, the hyperflexed forearm and arm are slipped and the whole is supported by tapes tied around the neck.

The after-care is too important not to have a few words said about it.

Prolonged hyperflexion necessarily results in contractures of the flexor muscles. Therefore, it is essential to diminish the flexion as soon as it is safe. This may be begun about the tenth day. At each dressing contrast baths, massage and passive motion are given. The range of motion should be limited by evidence of pain. Pain is indicative of injury to the part. Flexion and extension within a given

arc should be done once at each dressing during the early after-care of these patients.

Plaster molded splints should be used.

A source of annoyance is the tendency toward internal rotation, of the arm as a whole. This is due to the position of hyperflexion, which is accompanied by an internal rotation of the shoulder. In order to overcome this tendency, one must insist on rotation outward of the shoulder at the very earliest moment. Shoulder movement will not disturb the position of the fracture of the elbow if the bandage is snug. Some may consider these statements highly theoretical. To them, I commend neglect of this precaution, and they will later be convinced of the truth.

During the first twenty-four hours, it is urgent that the part be observed closely. Volkmann's ischemic palsy may result from a tight bandage which has been applied for as short a period as six hours. A case which was treated at Touro resulted from the bandage remaining on for twelve hours.



Fig. 28 (Case 18).—Result in case of posterior dislocation of humerus and supracondyloid fracture of humerus.

The application of the bandage in the position of hyperflexion requires special care. All bandages should include the hand. If the bandage does not include the hand, secondary swelling of the hand will be greater than that of the forearm, and any form of gauze sling around the wrist will cause a great constriction at this level. This will create a vicious circle. This difficulty can be overcome by bandaging the hand as well as the forearm and arm. A rubber tube used as a sling is preferable to a gauze bandage, because the elasticity of the former allows for relaxation if swelling occurs.

After the fourth week, it is very important that active as well as passive movement be encouraged. Massage and resistive exercises contribute in a large measure to a perfect result.

The following cases have been treated along these lines and represent the work as it is done in our clinic and private work.

CASE 13 (16,915).—J. D., aged 13 years, on April 2, while jumping rope, fell on his outstretched hands. He had had no treatment since the

accident. He had full use of his fingers, but could not raise his arm up to his head nor could he bend the elbow.

April 4, 1918: Examination under ether anesthesia revealed: right elbow, diminished carrying angle, cubitus varus, limited extension and flexion to about 130 degrees; pain on pressure over the internal condyle, crepitus over the internal condyle, and marked deformity. As soon as the deformity was reduced, we noticed a return of the carrying angle.

*Diagnosis.*—Fracture of the internal condyle of the humerus. The arm was placed in hyperflexion. Examination of the left arm revealed that it could be extended and flexed at will. On complete extension of the elbow, the internal condyle was seen to be more prominent. There was undue prominence of the internal condyle; no change in the contour, and small fracture of the internal condyle.

Roentgenogram 12902 revealed fracture of the internal condyle of the right humerus, and fracture of the internal condyle of the left humerus. April 9 and April 20, the arm was redressed. April 22, pronation and supination were unimpaired. There was no loss of carrying angle on either side. May 2, the left arm showed full extension and good flexion: the right arm could be extended to about 130 degrees without pain. All dressings were removed. Report of a roentgenogram, requested June 29, stated: "Suggestive of an old fracture, but



Fig. 29 (Case 21).—Result in case of fracture.

position is exceptionally good" (No. 14380). Examination, Nov. 20, 1920 (two years and a half after accident) revealed: perfect extension, perfect flexion, normal carrying angle, and no loss or limitation of pronation or supination (Figs. 20 and 21).

CASE 14 (17873).—*History.*—A. C., white, aged 10 years, admitted Nov. 21, 1918, with a supracondyloid fracture, the evening before had been pushed down while at school. When he fell, the arm went under him. He was unable to bend the elbow. He was treated by Dr. Levy in the emergency clinic.

*Examination.*—The left forearm was swollen; the carrying angle lost; the external condyle was lower than the internal condyle, and there was no alteration in the contour of the olecranon. Under ether anesthesia (Miss Armstrong) abnormal lateral mobility was noted. The deformity was reduced and the usual dressing applied. Roentgenogram 15272 revealed: Fracture lower end of the condyles of the humerus, epiphyseal separation of the olecranon process, epiphyseal separation of the head of the radius (Samuel).

*Treatment.*—November 30, hot and cold baths were employed. A splint was applied at a right angle. December 7, extension and flexion of the elbow were accomplished without pain. December 12, all dressings were removed.



*Outcome.*—The patient was seen during November, 1920. He had perfect extension and flexion of the elbow; no loss of carrying angle, and no loss of pronation and supination.<sup>3</sup>

CASE 15.—Feb. 10, 1917. G. M., boy, white, aged 12 years, was admitted with a fracture of the radius near the base— supracondyloid fracture of the humerus. He had fallen on the outstretched hand.

Examination revealed swelling about the elbow; abnormal lateral mobility, and crepitus. Above the wrist, there was a backward displacement of the hand on the forearm. Roentgenogram 98832 revealed: fracture of the lower end of the radius and supracondyloid fracture of the humerus (Fig. 22).

The deformities were reduced under anesthesia. Hyperflexion was maintained by light plaster splints.

March 13, 1917, flexion was 30 degrees, extension to 130 degrees. There was no pain and no deformity. March 24, he was able voluntarily to extend the elbow to 150 degrees without pain. There was no deformity. Pronation and supination were unimpaired (Fig. 23).



Fig. 30 (Case 21).—Result in case of fracture.

April 3, supracondyloid fracture position was fairly good. At my request the child appeared in the clinic Oct. 30, 1920. Examination at that time showed perfect function of the elbow, complete extension and flexion. There was no limitation of pronation nor supination. He had a normal carrying angle. A roentgenogram requested at this time revealed a normal elbow joint. About 2 inches above the level of the joint, there was evidence of a previous line of fracture (Figs. 24 A and 24 B).

*Comment.*—(1) The combination of a fracture of the base of the radius following a fall on the outstretched hand requires not only the hyperflexed position but in addition a palmar plaster splint.

3. The epiphyseal separation of the olecranon mentioned by the roentgenologist did not exist. It represents one of the stages of the normal development of the elbow as described in a previous paper (Footnote 2).

CASE 16 (20605).—H. G. aged 7 years, admitted Jan. 10, 1920, with a supracondyloid fracture of the left humerus. Sunday evening, Jan. 4, 1920, the patient had been running along the street when he fell in the gutter on his left arm. He came to the hospital the same evening and had a cast put on. He went home after a week's stay in the hospital. The arm was put up, January 10, in the Smith-Jones position. He returned January 12, and the arm was redressed. He has been anesthetized three times, once in my clinic. January 15, a right angle splint was applied.

January 24, flexion was limited and painful; a splint at 160 degrees was applied. Roentgen-ray report, Jan. 27, 1920: Old supracondyloid fracture of the left humerus, with some backward displacement of the lower fragment.

The child was resistant to any effort to do anything for him. The mother was advised to continue contrast baths and carrying of weights.

February 12, the child was resistant to treatment. The elbow was flexed and he would not allow one to extend it. The mother was advised of poor result unless she forced the child to carry out the treatment. He was able to extend the arm to about 150 degrees. He flexed the elbow to 60 degrees. Hot and cold applications and exercise were continued.

February 28, flexion and extension were still limited. Pronation and supination were limited. The same treatment was continued.



Fig. 31 (Case 22).—Result in case of supracondyloid fracture of the humerus.

March 13, flexion and extension were still slightly limited. There was still a large amount of callous surrounding the old fracture (supracondyloid). Forced hyperflexion was painful.

November, 1920, at my request, the child came to the clinic for observation. At this time, examination revealed: complete flexion, pronation and supination, and extension, and a normal carrying angle in both elbows (Figs. 25 and 26).

*Comment.*—The original attempts at reduction made by others did not succeed. When I saw the child, there was so much swelling that hyperflexion could not be maintained.

Persistent after-care will overcome many apparent muscle contractures.

CASE 17 (17923).—F. B., Harrahan, La., boy, white, aged 10 years, was admitted Nov. 5, 1918 with a supracondyloid fracture. He had fallen in a ditch, December 3, and had struck the left elbow. He was unable to straighten the arm or to bend the elbow. The left forearm was swollen. Measurements of the left elbow were 21 cm., right 17 cm. There was no pain over either condyle and no pain over the olecranon process. The head of the radius rotated with the shaft. He did not complain of pain along the course of the ulna. There was a diminished carrying angle. The fracture was reduced

under general anesthesia, and the usual dressing was applied. Roentgenogram 15365 revealed: epiphyseal separation lower end of the condyles of the humerus.

December 12: A right angle plaster splint was applied.

December 21: All dressing was removed.

April 22, 1919: There was no limitation of flexion or extension. The carrying angle was normal. The child said, when asked what he did with the arm, "I do all I want."

At my request the child came to the clinic Nov. 20, 1920. There was a normal carrying angle; no difference in the size of the two elbows; no limitation of flexion or extension of the two elbows. Pronation and supination were unimpaired (Fig. 27).

Roentgenogram 24247 revealed no visible bone injury of the left elbow (Nov. 20, 1920).

CASE 18 (17205).—A. K., boy, aged 10 years, admitted June 8, 1918, with a "posterior dislocation of the elbow—supracondyloid fractures." He had fallen from a bicycle the day before and had struck his elbow on the car track. He was able to raise the arm, but could not bend the elbow. Exam-



Fig. 32 (Case 22).—Result in case of supracondyloid fracture of the humerus.

ination revealed swelling and ecchymosis of the right elbow, abnormal mobility, no change in the contour of the ulna, abnormal mobility and crepitus just above the condyle.

Under ether anesthesia, the deformity was reduced. On account of the great amount of swelling around the elbow it was impossible to put it up in hyperflexion, anterior and posterior plaster splints were made, and the arm was put up at a right angle. A roentgenogram was requested.

June 13, the swelling had disappeared, and we were able to put the arm up in hyperflexion.

At my request the child came to the clinic, Nov. 18, 1920. There was no limitation of flexion nor extension, and no loss of carrying angle. Resistive exercise showed no loss of muscle power; if anything, the right arm showed better muscular development than the left (Fig. 28).

CASE 19 (21317).—R. L., girl, aged 3 years, was admitted June 17, 1920, with a supracondyloid fracture. She suffered pain in the left elbow. She had fallen from a sofa the night before and following the fall the arm hung by

her side. She cried a great deal, complaining of pain. There was swelling and ecchymosis of the left elbow. The lateral diameter was increased and there was a diminished carrying angle. Flexion and extension were limited.

Roentgenogram 21927, June 21, 1920, revealed a fracture through the condylar lower end of the humerus, the left elbow joint. Position was fairly good.

June 24, 1920: There was swelling of the elbow, with marked cubitus valgus. Under ether anesthesia, the deformity was reduced.

June 26, 1920: The child did not complain of pain; she could move the hand. The dressing was not changed; adhesive plaster reenforcement was applied. There was no swelling.

July 6, 1920: Flexion and extension were still slightly limited. A palmar plaster splint was reapplied.

July 10, 1920: The splint was removed. Contrast baths and exercise were employed. The arm was held in external rotation, and there was perfect flexion and extension.

CASE 20.—L. M., girl, suffered a supracondyloid fracture (impacted). While playing with one of her little friends she was thrown down and fell on the outstretched hand. On examination in the office, I found that there was swelling above the elbow, diminished carrying angle, cubitus valgus, and inability to flex and extend the elbow. A roentgenogram revealed supracondyloid fracture



Fig. 33 (Case 23).—Result in case of supracondyloid fracture of the humerus.

with impaction. Under gas anesthesia (Miss Armstrong), the impaction was broken up by hyperflexion, traction and counter traction, and I was unable to put the arm in acute flexion owing to the large amount of swelling which had taken place. It was put up at a right angle, that being all we could do at the time. The after-care was that usually given. January, 1921: The final result was perfect.

CASE 21 (15350).—E. G. B., boy, aged 10 years, suffered a fracture of the internal condyle of the humerus. While playing baseball, he threw the ball, and a sudden pain developed in the right elbow. There were pain, swelling, and abnormal mobility. The right elbow was larger than the left. The right measured  $7\frac{3}{4}$  cm, the left  $7\frac{1}{2}$ . The attitude was one of loss of carrying angle. He held the right arm partially extended. There was marked swelling above the internal condyle, and no change in normal relationship of landmarks of the elbow, but there was considerable pain over the internal condyle. Flexion beyond a right angle was impossible on account of pain. Bandages were removed and right angle splints were applied. Roentgenogram 10570 revealed "epiphyseal separation of the condyles of the humerus." Position was fairly good.

April 22, 1919, there was no limitation of flexion or extension. There was normal pronation and supination, and no deformity (Figs. 29 and 30).

CASE 22 (15805).—R. B., aged 10 years, suffered a fracture of the internal condyle. She fell from a wagon, July 27, 1917, and injured her elbow. Examination revealed complete loss of carrying angle, swelling of the elbow, pain over the internal condyle, and all motions about the elbow painful.

Roentgenogram 11142 revealed a supracondyloid fracture of the humerus. Position was good. Under ether anesthesia, the deformity was reduced, the carrying angle returned, and the elbow put in hyperflexion. On the tenth day the hyperflexed position was changed to one of right angle. There was no pain.

Sept. 13, 1917: Extension was possible to 160 degrees; flexion beyond 45 degrees. There was no pain nor deformity. The patient was advised to continue exercise.

Sept. 29, 1917: There were perfect flexion and extension.

Nov. 9, 1920: At my request the patient appeared in the clinic for observation, at which time the following was noted: carrying angle of both elbows was the same; there was no limitation of flexion, pronation or supination (Figs. 31 and 32).



Fig. 34 (Case 23).—Result in case of supracondyloid fracture of the humerus.

CASE 23 (18630).—G. O'B., aged 14 years, admitted June 13, 1919, with a supracondyloid fracture of the humerus, had fallen about 4 feet, striking the left arm on the pavement. There were swelling and pain around the elbow, an ecchymotic area over the external condyle, and crepitus on palpation. The transverse diameter of the elbow was increased. Under anesthesia the elbow was placed in hyperflexion.

Roentgenogram 16832: "The left elbow joint shows a supracondyloid fracture" of the left humerus. There is a splitting into the olecranon process of the ulna.

June 14, 1919: The patient had not suffered any pain.

June 22: The dressing was removed. There were ecchymosis and swelling over the external condyle. The arm was placed at a right angle in complete supination, and a plaster splint applied.

June 24: It was placed at an angle of 110 degrees.

June 28: It was placed in almost complete extension.

July 1: There were flexion to about 60 degrees and complete extension. A straight plaster splint was applied.

July 3: The splint was reapplied.

The roentgen-ray report was: "Repair of fracture previously observed is excellent; but there is a decided thickening of the periosteum throughout the lower shaft of the humerus," July 3, 1919.

One year and five months after the accident, Nov. 8, 1920, there was a normal carrying angle; perfect flexion and extension; no limitation of pronation nor supination (Figs. 33 and 34).

CASE 24 (21404).—E. C., aged 7 years, admitted July 3, 1920, with a fracture of the internal condyloid region (left), had fallen on his arm the night before. He slept that night; but there was immediate loss of function.

Examination revealed swelling of the left antecubital space, slight loss of carrying angle, and localized pain over the internal condyloid region. Flexion and extension were slightly limited and painful. The head of the radius rotated with the shaft. No crepitus could be felt. A roentgenogram was requested. Under ether anesthesia the arm was put in hyperflexion.

July 10: There was some ecchymosis and swelling around the external condyloid region. Extension and flexion were painful and limited. The arm was put up in right angle. July 15, flexion and extension were still limited and painful. The arm was put to 100 degrees. July 20: Extension was slightly limited and painful. Flexion was limited to 30 degrees. An anterior plaster splint was applied.

July 24: All splints were removed. Contrast baths and massage were advised.

July 29: Flexion and extension were still limited.

August 10: There was no deformity. Flexion of the forearm was still limited. Pronation and supination were not limited.

Nov. 9, 1920: I requested the patient to return for observation, at which time the following was noted: flexion and extension not limited; pronation and supination normal.

CASE 25 (13918).—C. H., aged 8 years, admitted July 1, 1916, with a supra-condyloid fracture of the humerus, had fallen in the gutter the afternoon before. She was treated in the emergency clinic by Drs. Park and Wall and me. Examination revealed swelling of the elbow, abnormal lateral mobility, and pain. The condyles and olecranon were in normal relationship to one another. The shaft was independent of the condyles. Reduction was accomplished under anesthesia, and acute flexion obtained. Roentgenogram 8602: Supra-condyloid fracture of the humerus; position of fragments not good.

The dressing was changed and a right angle position revealed.

April 22, 1919: Flexion and extension were normal. There was no loss of carrying angle. Pronation and supination were unimpaired.

CASE 26 (12954).—S. S., aged 11 years, admitted Nov. 27, 1915, with an old fracture of the internal condyle and ankylosis, four weeks before had fallen and hurt his arm. He was sent to the Charity Hospital where he was treated for fracture. He was discharged from the hospital and came to us. The arm was painful to the touch. Motion of the elbow was limited. There was deformity upward and backward at the elbow. Roentgenogram 7408: Fracture of internal condyle and fracture of the olecranon process. Position is not good.

April 22, 1919: There was no limitation of flexion nor extension. Pronation and supination were unimpaired. There was no deformity.

CASE 27 (18085).—S. B., aged 14 years, was admitted Jan. 30, 1919, with a fracture of the internal condyle. The history was written and roentgenogram 15668 was made March 1, 1919. The boy had fallen on his outstretched hand while playing leap frog. The roentgen-ray report was: fracture of the olecranon and other fractures. I examined the child, February 15. There was no pain over the olecranon, but pain over the internal condyle, and some limitation of flexion and extension, more of flexion.

A diagnosis of fracture of the internal condyle was made, and the arm was put in hyperflexion. Since that time, hyperflexion has been reduced until now, March 1, there is complete extension. All dressings were removed. The patient was advised to get a pair of dumb bells, and requested to return to clinic.

March 18: There was no limitation of extension or flexion. There was pronation and supination, and no pain. The use of dumb bells and contrast baths was advised.

April 22: There was no limitation of pronation and supination and no deformity.

CASE 28 (17650).—J. C., boy, colored, aged 9 years, was admitted Aug. 27, 1918, with a supracondyloid fracture. Ten days before he had fallen and struck his elbow (right). He had been unable to use the arm since the injury. The elbow was very much swollen. The child was put under ether anesthesia by Dr. Parish. The right elbow was swollen. The left elbow measured 8 inches; the right, 7½. There was no difference in the two condyles or the olecranons. Under anesthesia there was abnormal lateral mobility and crepitus. On account of the great amount of swelling, it was impossible to put the elbow up in hyperflexion, because of possible injury to the vessels. The arm was placed at a 160 degree angle, with a posterior plaster splint.

September 10: The dressing was removed, contrast baths and massage given, and splint reapplied.

September 14: Contrast baths and massage were given, a straight plaster splint was applied.

September 17: The dressing was not changed.

September 19: Pronation and supination were unimpaired. There was no pain and no loss of carrying angle. All dressings were removed. The use of dumb bells and contrast baths was advised.

October 5: The child was able to extend the arm almost completely.

CASE 29 (14710).—E. A., aged 5 years, suffered a supracondyloid fracture (left). She had fallen the day before (Nov. 24, 1916) while playing. Immediately there was loss of function. She cried all night and was in pain.

Examination revealed cubitus varus and swelling. There was pain in the internal condyle, and inability to flex the elbow.

Under anesthesia, reduction was made, and the arm was placed in hyperflexion.

Jan. 10, 1917: There was complete flexion and extension without pain and no deformity.

CASE 30 (17624).—A. H., white, aged 6 years, suffered a supracondyloid fracture.

While running the night before (Aug. 29, 1918) the child fell over a box and struck his elbow. He was treated in the Emergency Clinic on the same date and reduction was made by me.

Roentgenogram 14804 revealed: Supracondyloid fracture—position is fairly good (Dr. Samuel).

Examination under ether anesthesia revealed abnormal lateral mobility, some crepitus, and a loss of carrying angle. The arm was put up in the usual dressing.

The patient returned the next morning; he had no pain, and the dressing was allowed to remain unchanged.

September 17: The patient did not return for ten days; there was then some limitation of motion of the elbow, but particularly contraction was noted. The father of the patient was advised of the fact that he would have to return when told. The arm was put up at an obtuse angle. Contrast baths and massage were given. October 14, all dressings were removed. The use of dumb bells and hot and cold water was advised. The result was perfect.

CASE 31 (21,338).—L. T., colored, aged 13 years, was admitted, June 22, 1920, with a supracondyloid fracture of the left humerus. He had fallen from a bicycle three weeks before and injured the left arm. He had been to Touro several times for treatment.

An examination made three weeks before revealed loss of the carrying angle of the left arm. Cubitus varus and crepitus *above* condyle. There was increase of the lateral diameter. Under ether anesthesia the fracture was reduced, and the arm put in hyperflexion. Patient did not return as told until today. Flexion of arm was limited to 90 degrees and extension to 90 degrees. Plaster splint was applied.

Roentgenogram 22,045 revealed fracture of the lower end of the humerus; position very good.

July 6: Flexion was still limited to 90 degrees; extension normal. The splint was removed and the use of contrast baths was advised.

Final result: Perfect flexion and extension.

CASE 32.—L. G., aged 11 years, was admitted, June 10, 1919, with a supracondyloid fracture. He had fallen on the left arm eleven days before. He had been treated by Dr. Robinson in Pass Christian the day of the accident. There was no history of any pain. He was unable to straighten the arm.

The arm had been put at right angles by the other physician. There was evidence of pressure from the bandage. The patient was unable to straighten the forearm. Roentgenogram 16,829 revealed: Epiphyseal separation of the lower end of the left humerus.

Right angle plaster splints were applied. There was pain on extension over the external condyle; pronation and supination were not painful. The dressing was changed and the forearm put at a 110 degree angle.

June 26: The dressing was put on at an angle of 160 degrees.

July 1: Straight splints were applied. Extension and flexion were almost complete.

July 3: All dressings were removed. The mother was told to get two pound sand bags.

July 10: The child was afraid to use sand bags. He was able to extend his hand to an angle of 160 degrees, and to flex it beyond a right angle.

July 31: Complete extension and flexion were possible without any difficulty.

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## TORSION OF THE CECUM AND ASCENDING COLON\*

JOHN HOMANS, M.D.

BOSTON

Torsion or volvulus of the right side of the colon is one of the rare causes of intestinal obstruction. Though much less often mentioned in the literature than sigmoid volvulus, and less often encountered in surgery, it is probably of greater importance in the usual surgical clinic for adults, since twists and obstructions of the sigmoid are almost invariably associated with congenital megacolon (Hirschsprung's disease), a condition which in many instances becomes fatal or is successfully treated in infancy and childhood. Indeed, in this clinic, the count stands three cases to none in favor of the ascending colon.

The pathology of this accident rests on certain well studied congenital maldevelopments, plus a functional disturbance, in which a most interesting and little understood factor is the power of rapid gas formation possessed by the intestinal canal. As a *sine qua non* for the development of a twist of the right colon, it must have a mesentery. In addition, there may well be a displacement: of the cecum into the middle or left side of the abdomen, of the cecum upward, so that it is turned up against the liver, of the ascending colon, which may be displaced with the cecum, or (the cecum being fixed in its proper place) of the ascending colon as a downward hanging loop with or without attachment at its familiar angle beneath the liver. With the probable exception of the upturned cecum, such malformations are accounted for as failures of obliteration of the fetal mesentery rather than failures of descent of the right colon, a condition of little interest in this connection. Figures 1, 2, 3 and 4 illustrate these malformations.

In regard to the functional element in the causation of obstructive twists, physiologic studies by Cannon,<sup>1</sup> by Elliott and Barclay-Smith,<sup>2</sup> by Keith,<sup>3</sup> and others offer evidence of more than speculative interest. Cannon demonstrated that in the cat the receptively relaxed cecum and ascending colon, on receiving the liquid contents of the small intestine, undergo activity in the form of an antiperistalsis which

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\*From the Surgical Clinic of the Peter Bent Brigham Hospital.

1. Cannon, W. B.: The Functions of the Large Intestine, *J. A. M. A.* **59**:1 (July 6) 1912.

2. Elliott, T. R., and Barclay-Smith, E.: Antiperistalsis and Other Muscular Activities of the Colon, *J. Physiol.* **31**:272, 1904.

3. Keith, A.: A New Theory of the Causation of Enterostasis, *Lancet* **2**:371, 1915.

retards and churns their contents for a considerable period, a delay which favors equally fermentation and the absorption of fluid. This observation has since been confirmed and amplified by Elliott and Barclay-Smith. Whether or not the right colon of man is the seat of a similar process, the human colon, herbivorous in type, is undoubtedly the scene of the final fermentation and putrefaction of such food materials as are indigestible above; and, in particular, the cecum and ascending colon constitute a region of purposeful stasis and fermentative digestion.<sup>4</sup>

The government of the muscular activity of this region has likewise been considerably studied. Cannon, and subsequently Alvarez,<sup>5</sup> has shown in laboratory animals that contractions spreading from the lower portion of the ileum excite the initial activity of the beginning of the colon. In addition, there is a pacemaking area in the transverse colon, just around the corner from the ascending colon, which initiates the antiperistaltic contractions already described.<sup>6</sup>

According to Keith, this delaying station forms one of the most important members of a chain, of which two others are found in the large intestine, namely, at the rectocolic junction and above the anal canal.

It is clear then that the normally placed and fixed right colon is the seat of rather complicated physiologic activities on whose harmony depends the last of the digestive process and the formation and elimination of the feces. Familiar disturbances may well upset this harmony, bringing about unusual putrefaction and gas formation and leading in a dislocated or perhaps merely free bowel to acute distention, kinking and volvulus. Or, as has occasionally been reported, unusual muscular movements of the body, may, with or without such digestive

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4. For a discussion of antistalsis or anastalsis in the proximal colon, see Cannon, Footnote 1.

5. Alvarez, W. C.: Peristalsis in Health and Disease, *Am. J. Roentgenol.* **8**:1 (Jan.) 1921.

6. Gunn and Underhill (Experiments on the Surviving Mammalian Intestine. II. The Myogenic Origin of the Pendulum Movements, *Quart. J. Exper. Physiol.* **8**:285, 1914-1915) first demonstrated that the intestinal muscle, independently of any nerve supply, has the power of rhythmic contraction. This discovery controverted the earlier results of Magnus who found the presence of fibers of the myenteric plexus essential to such activity. Alvarez has abundantly demonstrated the power of the intestinal muscle independently to perform rhythmic contraction and has shown that it presents gradients starting from certain commanding stations, one of which is found in the region just distal to the ascending colon. This region again is indicated by Keith as abundantly supplied by peculiar branching cells not definitely of nervous or muscular nature but partaking of the character of both, and interpreted by him as a special development of the myenteric (Auerbach's) plexus. Alvarez would give the plexus a regulatory function only.

disturbances, produce the same result. In any case, once a kink or twist begins to interfere with the blood supply, the bowel so affected blows up rapidly, a fact noted many years ago by Treves,<sup>7</sup> who reports that the same result may be obtained experimentally. The mechanism of this rapid gas formation, which never takes place to the same degree proximal to the obstruction, is not understood.

In respect to the form or nature of the twist, descriptions in the older literature, based for the most part on fatal cases studied at necropsy, are perhaps misleading. One is more likely nowadays to see earlier stages on the operating table. Of present day value, however, is the observation by Treves of three forms of torsion. The first may involve the cecum and ascending colon in their own axis. In the second,

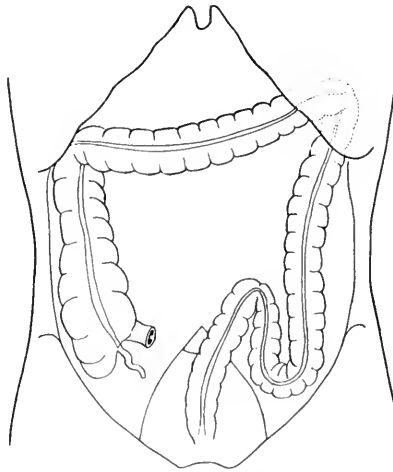


Fig. 1.—The theoretically normal colon. A much lower hanging transverse colon is usual.

the ascending colon may, with or without the cecum, possess so long a mesentery that it forms a loop which itself may rotate or become locked about another intestinal coil. In the third, the cecum may bend or twist on itself. The first variety, which does not necessarily involve any malformation or the presence of a *long* mesentery, is said to be very rare. The second, in which the ascending colon forms a loop, is about as frequently seen as the third, which occurs as a result of displacement or malformation of the cecum alone. One finds in the literature, a general agreement that twists occur clock-wise, an observation explained by von Zoege-Manteuffel<sup>8</sup> as due to the mesenteric

7. Treves, F.: *Intestinal Obstruction*, Ed. 11, New York, William Wood & Co., 1899, p. 13.

8. Von Zoege-Manteuffel: *Die Achsenderhungen des Coecums*, Verhandl. d. deutsch. Gesellsch. f. Chir. **27**, Part 2:546, 1898.

attachment of the ileum. Basing his conclusions on twenty collected cases and four of his own, this observer concludes that torsion to 180 degrees may occur in the axis of the bowel without interfering with its blood supply, but that if the twist goes beyond this point, the mesentery, which is necessarily present, becomes strangulated.

The importance of all these etiologic factors is easily seen when one faces the treatment of this condition. For having them in mind, one can more easily decide on simple drainage, fixation, or resection of the diseased colon. The three patients whose cases are herewith described had suffered for years from obscure abdominal complaints which apparently culminated in acute torsion; and whatever palliative treatment might previously have been indicated, operation was finally in all instances imperative.

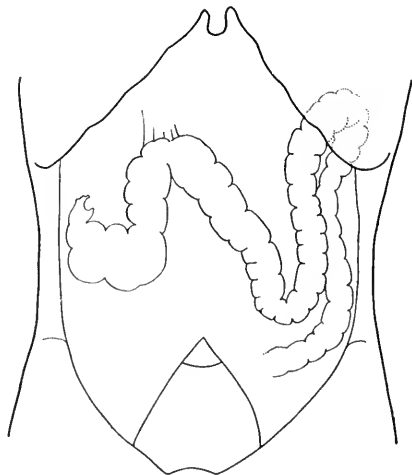


Fig. 2.—Sketch made from roentgenogram. The cecum is fixed in a high position. (A defect due to an early cancer is seen at its tip.) The ascending colon has a mesentery and hangs down below and mesial to the cecum. The hepatic flexure is attached rather near the midline.

#### REPORT OF CASES

CASE 1.—*History*.—E. C. M. (Surg. No. 5,222), female, aged 32, three years before entrance to the hospital, had been operated on for appendicitis. Since then she had suffered a number of attacks of acute low abdominal colic, accompanied by distention and constipation. Milder attacks were relieved by lying on the left side, after which the patient passed gas and felt better. The more severe attacks lasted from four to five hours and were relieved by enemas. She was awakened three days before entrance to the hospital by colicky abdominal pain. Cathartics and enemas gave no relief. Since then the abdomen had become distended. The abdominal enlargement was first noted on the left of the umbilicus and was accompanied from the start by visible peristalsis. The patient constantly vomited food taken, but no regurgitation of intestinal contents occurred.

*Examination.*—On entrance, the patient's temperature was 100 F., pulse 96, white count 12,000. There was a median scar below the umbilicus. The abdominal distention was most marked in the region just below the umbilicus, beginning a little to the left of the midline and extending upward to the right for about 8 inches. The right iliac fossa was a little less distended. There was no fulness in the flanks. It was noted that in spite of what appeared to be obstruction in the lower ileum, the patient did not look particularly sick.

*Operation.*—At operation, through a right rectus incision, the cecum and lower ileum were found adherent to the upper end of the median scar and to the posterior abdominal wall as well. The cecum had then pushed downward and to the left through the attachments thus formed, and had twisted, as one looked at the cecum from above, clock-wise. (The exact amount of the torsion was not recorded; certainly not more than 180 degrees.) The cecum was enormously distended, thin-walled, but not notably cyanotic. The adhesions were divided. After tying in a Mixer tube, it was possible to replace the cecum and ascending colon in their normal position. The patient made a good recovery, the colostomy closed naturally in about three weeks, and aside from her habitual constipation, the patient, during the five years which have followed her operation, has been well.

The postoperative condition of the cecum, ascending colon and large intestine in general is well illustrated in Figure 5, a sketch made from a roentgenogram of a barium enema. There is evidently considerable redundancy of the large intestine both on the right and left side, a tendency noted by Leichtenstern,<sup>9</sup> Curschmann,<sup>10</sup> and others in their studies of large intestine abnormalities.

CASE 2.—*History.*—J. E. McG. (Surg. Nos. 11,969 and 12,220), male, aged 53, for fifteen years had experienced attacks of discomfort confined to the lower abdomen and appearing after meals. At first, these attacks appeared about once a month. For the last two years, they had become more frequent and severe, lasting sometimes from five to six hours. Induced vomiting had always given relief.

Ten days before admission to the hospital, the attacks began to appear daily, the pain, of a dull grinding character, became more severe and vomiting followed the taking of food. The bowels continued to move naturally until four days before entrance when an enema gave a good result. From that time on there were no movements.

*Examination.*—On admission, the temperature was 98 F., the pulse 84, and the white count 25,000. The patient was somewhat cyanotic but did not appear very sick. The abdomen was moderately and symmetrically distended. There was evidence of a little fluid. A cleansing enema gave a fair gas result, and a barium enema disclosed in the roentgen-ray examination the condition shown in Figure 6, a sketch taken from the roentgenogram. The cecum was enormously distended and the ileocecal valve dilated.

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9. Leichtenstern, O.: Verengerungen, Verschlüssungen und Lageveränderungen des Darms, *Handbuch der Speciellen Pathologie und Therapie* 7, Part 2:361, 1876.

10. Curschmann, H.: Topographisch-klinische Studien, *Deutsch. Arch. f. klin. Med.* 53:1, 1894.

*Operation.*—Lying in the midabdomen was an enormous tense cecum, whose walls were beginning to split along one of the longitudinal bands. There appeared to be no interference with the blood supply. After needle puncture of the bowel had emptied the cecum and ascending colon, palpation demonstrated that the transverse colon was collapsed and the hepatic flexure fixed. A twist could not be demonstrated. Cecostomy was followed by a good recovery.

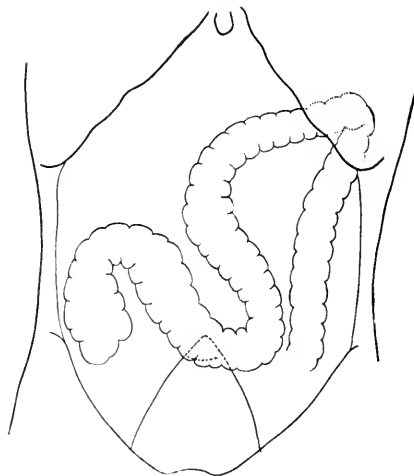


Fig. 3.—Sketch made from roentgenogram. The cecum is normally fixed. The ascending colon has a long mesentery and hangs down into the pelvis. There is no hepatic flexure.

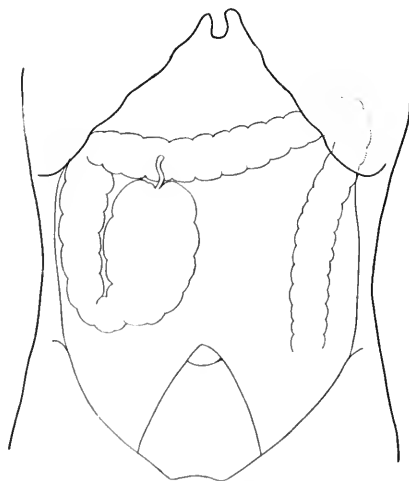


Fig. 4.—Sketch after Curschmann. The cecum has been "hung up" in its descent. The upper part of the ascending colon is normally placed and fixed.

After the opening had spontaneously closed, the bowels moved well and roentgen-ray studies revealed a normal passage of food through the intestines. Within a week after closure of the colostomy, the attacks recurred, causing the patient again to enter the hospital. Relief by enema has been followed by normal health up to the present, one year later.

Evidently the fixation due to the cecostomy has cured this patient. The lesion here was possibly a valvelike kink rather than a twist. The barium examination previous to operation showed that fluid could enter the ascending colon from below but could not return, and since a twist would probably have disturbed at least the venous circulation, absence of cyanosis in the bowel wall suggests that no twist existed. In this respect this case somewhat resembles Case 3.

*CASE 3.—History.*—M. E. B. (Surg. No. 13778), female, aged 44, had been troubled all her life by "indigestion." For the last eighteen years, she had suffered at irregular intervals from attacks of nausea and constipation alternating with diarrhea. For these attacks, which, if untreated, lasted many days, she had learned to take castor oil followed by a glycerin enema. She then passed a good deal of foul material and mucus by rectum, and went on as before. Removal of the appendix two years after the beginning of her illness had not affected this condition.

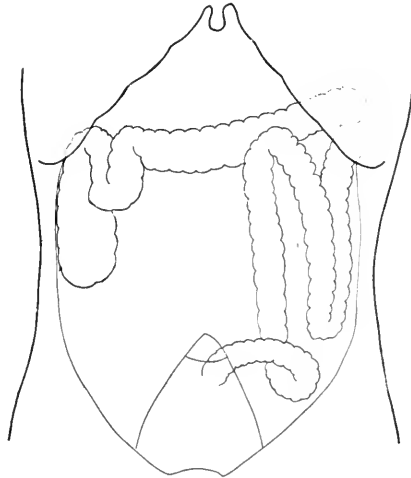


Fig. 5. (Case 1).—Sketch made from roentgenogram showing postoperative condition. The cecum and ascending colon are now in normal position and apparently fixed (following colostomy and operative trauma). There is a redundancy of the ascending (or transverse) colon. The extraordinary loop of descending colon may be noted.

Ten days before entrance to the hospital, one of the familiar attacks began, but was not relieved by the usual remedies. Up to the day of entrance, the patient felt nauseated and uncomfortable at times. Feeling more abdominal discomfort on this day, she took a glycerin enema with fair result, but within half an hour she began to suffer the very same cramplike pain in the right iliac fossa, which six hours later led to operation. Morphine ( $\frac{1}{4}$  grain) gave little relief. At the same time, a swelling appeared in the abdomen close to the right flank and steadily increased in size until, when seen in the evening, an elongated rounded mass occupying the normal position of the cecum and ascending colon was very evident. This mass was tender to touch, but elsewhere, the

abdomen was soft and not distended. The patient's temperature was subnormal; the pulse rapid. She was evidently in moderate shock. A diagnosis of torsion of the cecum and ascending colon was made.

*Operation and Results.*—Six hours after onset, a muscle splitting incision was made in the right flank. There was a little free clear fluid in the abdomen. A much dilated large intestine of dusky color appeared, running from the rib border to the iliac crest. At first sight, this appeared to be the ascending colon; but when collapsed large intestine was seen in the flank outside it, the dilated intestine was thought to be a descending turn of the transverse colon lying in shotgun fashion median to the ascending. The patient's rather feeble condition permitted nothing more than a colostomy, made with a Mixer tube. The contents of the distended colon were for the most part a clear greenish-brown fluid, sometimes stained with dark blood. A good deal of gas was evacuated.

Twenty-five days later, the patient had passed little or nothing by rectum. Enemas, however, had always come out through the colostomy. Evidently there

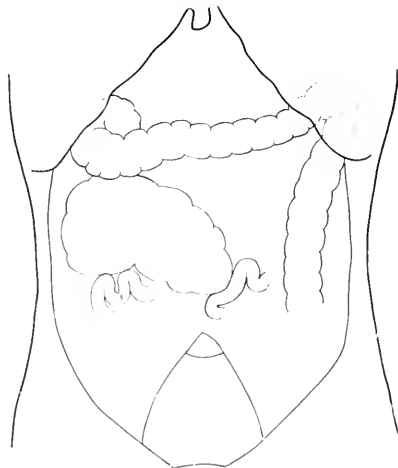


Fig. 6 (Case 2).—Sketch made from roentgenogram taken before operation. Position and enormous dilatation of cecum may be noted. The possibility of a kink in the ascending colon is easily understood. Regurgitation into the small intestine is suggested by the few coils of small intestine shown.

was a valvelike obstruction to the passage of material from above. A barium enema was unsatisfactory. Operation at this time disclosed the condition shown in the accompanying illustration (Fig. 7). The cecum lay in normal position, held down rather firmly by a Jackson's veil. The ascending colon passed upward for perhaps 6 inches (offering an explanation of the collapsed bowel seen outside the distended loop at the first operation) and then turned downward and forward, making a considerable loop. This loop possessed a *fairly long mesentery*. At its distal end, the loop passed back to the hepatic flexure, which like the cecum was firmly fixed. Since there seemed reason to believe that without resection, the kinking (and torsion?) would recur, the cecum, ascending and beginning of the transverse colon were resected, and the ileum anastomosed end to side into the transverse colon.

Four months later, at the time of writing, the patient has picked up in weight and strength. She has had no further "attacks."



## COMMENT

The question arises here, as in the second case, whether or not a true torsion has occurred. Certainly, the failure of feces to pass, even when the colostomy had nearly closed, was not due to torsion but to a valvelike kink. Yet one can hardly believe that a kink at both ends of the loop, distal to the collapsed cecum, could have caused, unless sufficient torsion to interfere with the circulation had occurred, such sudden local distention. Even though no twist was demonstrated at the first operation (since the patient's condition contraindicated a satisfactory exploration) it is highly probable that one existed.

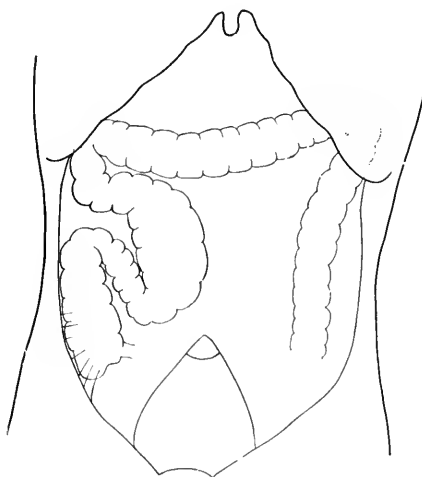


Fig. 7 (Case 3).—Sketch made from operative notes and diagram. The redundant ascending colon and its mesentery are represented as being turned inward. The cecum is fixed by a veil. The hepatic flexure is normally placed and fixed. At operation, the cecum, though proximal to the distended loop, was collapsed. The loop was blocked at both ends.

These three cases represent what has so frequently been described as torsion or volvulus of the right colon. In the first case, the anatomic abnormality, a very free cecum and ascending colon, might never have caused symptoms without the fixation of the ileum and cecum by adhesions, following the patient's acute appendicitis (operated on, by the way, through a median incision). Nevertheless, unusual distention of an unusually mobile ascending colon probably forced the cecum and lower ileum through a bridge of adhesions and so led to the twist. And the tendency to congenital abnormality is further demonstrated by the remarkable loop of descending colon shown in Figure 5. The case falls into Treves' second class.

In the second case, torsion is not actually proved. There will be noted in the sketch made of the preoperative roentgenogram (Fig. 6) a redundancy of the ascending colon. At operation, however, no note was made either as to the presence of a mesentery or of a twist of the bowel. Torsion is possible but unproved, and the condition cannot be considered as falling into any particular classification.

A comparison of the sketch of the ascending colon in the third case (Fig. 7), with the diagrams (Figs. 2 and 3) made from roentgenograms and sketches found in Curschmann's paper, shows that this type of anomaly is quite common. With less complete fixation of the hepatic flexure and cecum, it would doubtless have been harmless. And though the condition has been classified as torsion, it must be admitted that since the bowel was found at operation to lie in its normal direction no twist of the mesentery could possibly have taken place. Any torsion which may then have occurred must have been in the axis of the bowel.

Volvulus and torsion are evidently unsatisfactory terms for such conditions as these, but once established they may well stand. They form a sufficiently definite entity to permit a diagnosis before operating, more especially when there is obtained a long history of colicky attacks evidently linked with the larger intestine by their association with constipation or diarrhea. When such attacks are relieved for long periods by such means as enemas, by the patient's assumption of particular positions, or as in one instance here, by induced vomiting, one may fairly suppose that an intestinal deformity is responsible. And finally, when local distention, whether or not supported by the evidence obtained from roentgen-ray study of the barium enema, can be made out, the actual location of the twist or kink may be inferred.

A series of three cases is perhaps too small from which to draw conclusions as to treatment, but at least it offers evidence that a simple colostomy may be curative. As the initial procedure, a cecostomy is certainly sound. In the absence of actual necrosis of the intestine, it should be sufficient until roentgen-ray study and the behavior of the intestine during closure of the colostomy give some indication as to the future patency of the intestine. In view of the acutely ill condition of many of these patients, any other emergency operation will seldom be practicable. Resection of the malformed or malplaced intestine should undoubtedly be reserved for patients with established necrosis of the bowel and for those whose right colon is clearly incapable of functioning in a normal manner.

## BLOOD NITROGEN ESTIMATIONS IN GENITO- URINARY AND ABDOMINAL CONDITIONS

J. W. VAUGHAN, M.D. AND P. F. MORSE, M.D.

DETROIT

A most complete review of chemical changes in the blood in disease has been presented in a series of articles published in *The Journal of Laboratory and Clinical Medicine* by Victor C. Myers.<sup>1</sup> These articles sum up the present knowledge concerning this most interesting phase of diagnostic and prognostic medicine.

Blood chemistry, as the term is now used, is practically the result of the investigations of American research workers,<sup>2</sup> unaided by the work of any foreign observer, and consequently we can be justly proud of the benefits derived from these investigations. Folin, Benedict, Myers and Van Slyke have been the forerunners in this work, and it is because of their labors that something really new and of practical importance in the every-day practice of medicine has been evolved. As not infrequently happens, a research work intended to be of benefit chiefly to medical practice, has, I believe, proved to be of even more value to the practicing surgeon, and it is only with these facts that we wish to deal.

At the present time, the one important surgical aid has been the estimation of nonprotein nitrogen and the changes observed in this substance in the circulating blood. This is of value chiefly in lesions of the genito-urinary system, and in intestinal obstruction. As Myers has shown, the urea nitrogen estimation is also of value; but the work that has been performed in the laboratory at Harper Hospital shows

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1. Myers, V. C.: Chemical Changes in Blood in Disease, *J. Lab. & Clin. M.* **5**:343 (March) 1920; *ibid.* **5**:418 (April) 1920; *ibid.* **5**:490 (May) 1920; *ibid.* **5**:640 (July) 1920; *ibid.* **5**:700 (Aug.) 1920; *ibid.* **5**:776 (Sept.) 1920; *ibid.* **6**:17 (Oct.) 1920.

2. Folin, Otto, and Wu, Hsien: *J. Biol. Chem.* **38**:81 (May) 1919; *ibid.* **41**:367 (March) 1920. Okada, S.: Amino-Acid Nitrogen in Blood, *J. Biol. Chem.* **33**:325 (Feb.) 1918. Steinfield, Edward: Bedside Determination of the Blood Urea Nitrogen, *J. A. M. A.* **75**:473 (Aug. 14) 1920. Hammett, F. S.: *J. Biol. Chem.* **41**:599 (April) 1920. Pemberton, Ralph, and Foster, G. L.: Studies on the Nitrogen, Urea, Carbon Dioxid Combining Power, Calcium, Total Fat and Cholesterol of the Fasting Blood, Renal Function, Blood Sugar and Sugar Tolerance, *Arch. Int. Med.* **25**:243 (March) 1920. Gettler, A. O.: Value of Modern Blood Chemistry to the Clinician, *J. A. M. A.* **71**:2033 (Dec. 21) 1918. Schnabel, T. G.: Blood-Cholesterol in Gastro-Enterological Cases, *Am. J. M. Sc.* **160**:423 (Sept.) 1920. Chabanier, H., and de Castro Galhardo, A.: *Presse med.* **28**:653 (Sept. 18) 1920.

that for practical purposes the more easily and rapidly performed estimation of the nonprotein nitrogen furnishes the surgeon with sufficient information for his guidance as to the proper procedure in any given case in which blood chemical findings are desired.

With regard to prostatic obstruction Myers states that "the blood urea has been found to be a very valuable preoperative prognostic test in cases of prostatic obstruction. Cases showing urea nitrogen figures under 20 mg. per 100 c.c. of blood may be regarded as good operative risks as far as the kidneys are concerned. When the urea nitrogen figures are found between 25 and 30, the patient should be operated on with considerable caution and best after a period of preliminary treatment directed to relieve the nitrogen retention. Urea nitrogen figures over 30 mg. are very good evidence of renal involvement and, therefore, afford a rather poor operative prognosis."

When estimating nonprotein nitrogen, the same statement might apply with a change only in the figures given. Any operation in which the nonprotein nitrogen registers more than 60 mg. to 100 c.c. of blood becomes a case in which the risk is increased, and it has become our practice to perform an operation in either one or two stages, using the nonprotein blood nitrogen estimation as the chief guide.

A few words concerning the estimation of the nonprotein blood nitrogen may not be amiss. As Myers points out, the percentage of this form of blood nitrogen is not a constant factor, there being a greater amount present after a meal containing protein than before. For such reasons a finding of from 25 to 30 mg. per 100 c.c. is now estimated as normal, while an increase to 35 or above would be classed as pathologic. We have reviewed about fifty charts and laboratory records representing cases in which a blood nitrogen has been requested by various surgeons at Harper Hospital. These cases have all been abdominal or genito-urinary in character. From these charts, cases have been selected which show something of definite value and which will aid in the proper understanding of this procedure as a diagnostic or prognostic aid. All cases in which a correct diagnosis could not be substantiated, either by subsequent history, subsequent postoperative findings or postmortem examination, have been discarded.

The estimation of the nonprotein nitrogen in any blood sample is made in the following manner, or by some modification of it: To a given amount of blood, sodium tungstate and sulphuric acid are added to precipitate the proteins. Next a micro-Kjeldahl digestion of the nonprotein nitrogenous material is made, and the ammonia is nesslerized and estimated colorimetrically. The technic followed is that described by Folin and Wu.<sup>2</sup> Inasmuch as not more than 5 c.c. of blood

is required for such a test, it can be seen that repeated examinations can be made without hardship or danger to the patient which, in itself, is a very important factor, inasmuch as a study of our cases convinces us that repeated examination at given intervals of four hours or more furnishes valuable information, while single examinations may be so misleading that the surgeon may form decidedly erroneous conclusions.

The following series is composed of thirty-nine cases, which have been selected as stated before. Of these cases, sixteen are genito-urinary and twenty-three represent gastro-intestinal pathologic conditions. The genito-urinary cases may be further divided thus: urethral obstruction, 2; pyonephrosis, 3; renal calculus, 1, and hypertrophy of prostate, 10.

The gastro-intestinal cases may be subdivided thus: intestinal obstruction (high), 5; intestinal obstruction (low), 7; acute gangrenous appendicitis, 5; strangulated hernia (bowel recovery), 2; strangulated hernia (enterostomy or resection), 1; intestinal paresis, 5, and gastric paresis, 1.

In order to present more clearly the points that we desire to elucidate it will be necessary to present certain facts regarding each case in more or less detail.

#### REPORT OF CASES

##### GROUP 1.—GENITO-URINARY

CASE 1.—C. H. N. entered Harper Hospital May 28, 1920, and died June 1, 1920. The diagnosis was urethral obstruction with periurethral extravasation of urine and pus, which extended into the scrotum and through the lower portion of the abdominal wall. Operation consisted solely in multiple incision and drainage throughout the infected area. The onset of symptoms had been five days previously, at which time the patient had first noticed pain during and after micturition, and the scrotum had begun to swell. A postmortem examination showed the scrotum to be 6 inches in diameter, edematous and with many areas of beginning gangrene. The bladder wall was hypertrophic and thickened. There was no gross evidence of cystitis. A large periurethral abscess was found near the posterior portion of the urethra reaching backward and involving the right lobe of the prostate. The pelvic tissues and the tissues around the seminal vesicles were diffusely infiltrated, producing a pelvic phlegmon with pus of the same character as that found in the abdominal wall.

One blood nitrogen estimation made, May 29, 1920, revealed 25 mg. of nonprotein nitrogen per 100 c.c.

*Comment.*—It is evident that this patient succumbed to sepsis following the rather rapid formation of a periurethral abscess. The interesting point to note is that in spite of the fact that urinary obstruction reached a stage when it was so great that most of the urine was passed into the tissues, yet there was apparently not sufficient back pressure to cause any registerable kidney injury.

CASE 2.—Mr. N. K. entered Harper Hospital, July 8, 1920, complaining of frequent urination, necessitating the passage of urine every two hours. There

was considerable difficulty in starting the stream and there was dribbling before and after urination. The duration of pronounced symptoms was four months. The bladder was distended. Examination revealed a urethral stricture, which was dilated.

Blood nitrogen determination, July 9, 1920, revealed 30 mg. per 100 c.c.; uric acid, 5 mg. per 100 c.c.

*Comment.*—This is a second case in which there was evidently retention of urine caused by partial obstruction in the genito-urinary system below the level of the muscular control of bladder outlet. Again there was no evidence of marked renal involvement due to back pressure, although the high uric acid may denote some degree of kidney injury.

CASE 3.—E. W. entered Harper Hospital, June 20, 1920. The diagnosis was left pyonephrosis following complete retention of urine for a period of two weeks. The patient had been catheterized entirely during this period. The pathologic condition requiring this procedure was recorded as a stricture of ten years' duration. The blood nitrogen determination, June 20, 1920, read 240 mg. per 100 c.c.; June 23, it was 300 mg. per 100 c.c., and June 24, 600 mg. per 100 c.c. was recorded.

Inasmuch as this was the highest estimation that had ever been encountered, doubt was entertained concerning its accuracy. Consequently a specimen of blood was sent to the Detroit Clinical Laboratory where the result was confirmed. In spite of the extremely high nitrogen estimation, this patient progressed favorably under drainage of the bladder through a catheter, and subsequent blood nitrogen estimations showed a return to normal.

*Comment.*—This is an extremely interesting and instructive case showing that in acute obstructive conditions of the lower genito-urinary tract a remarkably high blood nitrogen finding is not invariably fatal, and consequently cannot be used as a prognostic aid as we had previously hoped. It is also to be noted that a stricture causing complete retention may be followed by grave renal injury, especially in the presence of infection.

#### GROUP II.—PYONEPHROSIS

CASE 4.—Mrs. G. R. entered Harper Hospital, March 28, 1920, and died, April 18, 1920. The diagnosis at the time of entrance was left pyonephrosis. The urine contained from 40 to 50 pus cells to a field.

A cystoscopy performed, April 7, 1920, showed thick pus coming from the left ureter. Microscopic examination of this pus demonstrated the cells to be chiefly polymorphonuclear leukocytes. Cultures were negative and no tubercle bacilli could be found. Roentgen-ray examination failed to reveal any calculus. Urine examination gave an acid urine of 1.015 specific gravity. It contained considerable albumin, no sugar, much pus and many red blood cells.

One hour after cystoscopic examination, the patient suffered a severe chill, which was followed by a rapid pulse and lowered temperature. Vomiting commenced next day, but toward evening the patient appeared much better. The seventh day vomiting began again, and the patient died April 18, 1920.

April 16, 1920, the blood nitrogen showed 300 mg. per 100 c.c.; April 18, 1920, the day of death, 300 mg. per 100 c.c. The blood pressure, April 16, was 155 systolic and 110 diastolic.

*Comment.*—It is unfortunate that no blood nitrogen estimations were recorded before cystoscopy was performed as it is impossible to state, without such knowledge, what evidence there was of right kidney insufficiency before this procedure. However, we believe that we are safe in surmising that cystoscopy

with catheterization of the infected kidney only may not be in all cases the harmless procedure that we usually think it to be. Whether it was this procedure, or some other condition occurring coincidentally that was responsible for the fatal outcome cannot be said, but this case shows that when only one kidney is functioning, injury to the good kidney may result without much trauma and may rapidly prove fatal.

To show the value of the blood nitrogen estimation in ascertaining the function of one good kidney, the following case is added because of its similarity.

CASE 5.—Mrs. Z. entered Harper Hospital, Feb. 10, 1920, and was discharged, March 7, 1920. The diagnosis was right pyonephrosis of six years' duration. This case showed pure pus composed chiefly of polymorphonuclear leukocytes coming from the right ureter. There were also a few red blood cells and a trace of albumin. Examination for tuberculosis was negative; staphylococci were present. The urine from the left ureter was negative.

The blood nitrogen taken, Feb. 12, 1920, showed 31 mg. per 100 c.c.

The operation performed, Feb. 14, 1920, furnished these findings: The kidney was found to be so fixed with adhesions and so friable that delivery was impossible. An opening was made through the necrotic kidney substance, and about 1 pint of pus escaped. The kidney substance was next dissected away on all sides, leaving the remnants of the greatly dilated pelvis. This was packed with gauze and its sides sutured to the abdominal wall. Pathologic examination of the tissue removed showed "an old chronic pyonephrosis with complete destruction of the kidney parenchyma. There is a marked overgrowth of lipoidal endothelial cells unusual in simple pyonephrosis and suggestive of gummatous origin." Parenthetically, it might be stated that the routine Wassermann test had proved negative. While at the time of the operation the symptoms were severe, the patient suffering from pus retention with rapid pulse and temperature, yet the convalescence was uneventful, and a urine examination made nine months later, Nov. 1, 1920, showed nothing abnormal.

*Comment.*—This case would seem to show the value of blood nitrogen estimations when seeking information concerning the condition of the functioning kidney after one had been completely destroyed by an infectious process.

#### GROUP III.—RENAL CALCULUS

CASE 6.—Dr. P. entered Harper Hospital, April 11, 1920. This patient gave a typical history of calculi in both kidneys, which had been confirmed by roentgen-ray examination. While there are several cases of unilateral kidney stone that have showed no change in the blood nitrogen percentage, this is the only case in which the condition was bilateral and in which an estimation had been made.

The phenolsulphonephthalein test showed: left, fifteen minutes, 5 per cent.; thirty minutes, 9 per cent.; right, twenty-three minutes, 5 per cent.

A later test of bladder urine gave these results: fifteen minutes, 12½ per cent.; one hour, 15 per cent., and two hours, 2½ per cent., a total of 30 per cent. in two hours.

The urine contained blood and albumin, but was otherwise negative. Blood nitrogen estimated, April 13, 1920, showed 23 mg. per 100 c.c.

An operation was performed and the recovery was uneventful. This case is reported simply to illustrate the fact that bilateral calculi do not necessarily interfere with kidney function.

## GROUP IV.—HYPERTROPHIC PROSTATE

CASE 7.—J. P. entered Harper Hospital, Feb. 9, 1920, and died Feb. 15, 1920. The diagnosis was hypertrophied prostate, and the symptoms showed that the condition had existed for at least five years. For the last week this patient had been catheterized twice daily. There was a cystitis. Two years before presenting himself for operation, his urine was said to have contained 1 per cent. of sugar. The residual urine at the time of operation was from 200 to 250 c.c.

Feb. 12, 1920, the blood nitrogen was 66.6 mg. per 100 c.c.; the blood sugar was 0.12 per cent.

He was operated on Feb. 14, 1920, a one-stage suprapubic prostatectomy being performed. The pathologic report showed an adenomatous hypertrophy of the prostate. No exact record of the amount of urine passed each day after operation was recorded. He died, Feb. 15, 1920, at noon, and on that day 6 ounces of urine were passed.

*Comment.*—This is a case in which a blood nitrogen of 66.6 mg. per 100 c.c. proved fatal in a one-stage operation. This, of course, would suggest active renal impairment before operation was instituted. Parenthetically, it might be noted that our present method of measuring the amount of urine passed in cases in which a suprapubic prostatectomy has been performed is too inaccurate to be of any scientific value. Besides recording the amount passed through drainage tubes, it is necessary to weigh dressings before and after application to estimate the amount of urine excreted. We have perused several charts in which the cause of death was given as uremia when the amount of urine excreted up to the time of death, together with the blood nitrogen estimations, has shown that such a condition was practically impossible, and that the true cause of death was sepsis.

CASE 8.—J. H. entered Harper Hospital, March 22, 1920, and died, April 27, 1920. The history and examination revealed a prostatic obstruction of seven years' duration. Lately it had been necessary to catheterize. No blood nitrogen was recorded before the first operation, which was performed, March 23, 1920. This consisted of a suprapubic drainage performed under local anesthesia. March 27, the blood nitrogen was 66 $\frac{2}{3}$  mg. per 100 c.c.; April 5, it was 52 mg. per 100 c.c.; April 12, it was 60 mg. per 100 c.c., and April 19, it was 46 mg. per 100 c.c. On this date prostatectomy was performed.

April 21, the patient developed a facial erysipelas which proved fatal. April 26, the blood nitrogen registered 75 mg. per 100 c.c. The urine showed a trace of albumin and much pus.

The pathologic report showed a fibrosis of the prostate with a low grade periglandular round-cell infiltration.

*Comment.*—This case illustrates the recovery of kidney injury following suprapubic drainage in prostatic hypertrophy and the advisability of performing a two-stage operation. It is unfortunate that an outside complication made the issue fatal.

CASE 9.—J. B. entered Aug. 2, 1920. A suprapubic puncture had been performed one year before, following progressive prostatic symptoms of three years' duration. He had had to be catheterized ever since the puncture. For the last three days he had had chills and fever. Aug. 3, 1920, a suprapubic puncture was performed. Aug. 5, 1920, the blood nitrogen was 70 mg. per 100 c.c.; creatinin 2 mg.; sugar 0.1 per cent. August 18, a suprapubic prostatectomy was performed.



Sept. 10, 1920, the blood nitrogen was 52 mg. per 100 c.c.; 2.1 creatinin; September 11, blood nitrogen, 86 mg. per 100 c.c.; 2.7 creatinin; September 13, blood nitrogen, 86 mg. per 100 c.c.; 2.7 creatinin; September 25, blood nitrogen, 39 mg. per 100 c.c. The urine was acid, with a specific gravity of 1.022. There was a trace of albumin and considerable pus.

The pathologic report showed marked glandular hypertrophy, with early carcinomatous changes. There was a chronic inflammation of the stroma with increased connective tissue, and prostatic calculi were present.

*Comment.*—The apparent interpretations of the blood nitrogen readings in this case would be a decided interference with kidney function after suprapubic puncture was made. This was again followed by another such increase, which was noted up to twenty-five days after the radical removal which was followed by a normal reading twelve days later.

CASE 10.—J. A., aged 76, who entered, June 24, 1920, gave a history of prostatic hypertrophy which had progressed to such an extent that catheterization was frequently necessary. The phenolsulphonephthalein test was: first hour, 20 per cent.; second hour, 25 per cent. The blood pressure was 180 systolic and 100 diastolic. June 28, a suprapubic puncture, with permanent tube drainage, was instituted.

The blood nitrogen, June 24, was 30 mg. per 100 c.c. The blood nitrogen, July 2, was 20 mg. per 100 c.c.

July 20, suprapubic prostatectomy was performed. The patient died, July 18, death being attributed to uremia.

This represents a bad risk in which, according to blood nitrogen readings, the prognosis should have been favorable. The diagnosis of uremia as the cause of death is not in accordance with these findings. Unfortunately, no urinary output estimations were made following the prostatectomy.

CASE 11.—C. B. entered Harper Hospital, Feb. 10, 1920, and died Feb. 17, 1920. He gave a history of hypertrophy of the prostate. It had been much more difficult to urinate for the last two weeks, and he had suffered complete retention for the last twenty-four hours. The blood pressure was 140 systolic and 70 diastolic. The white blood count showed 10,000 cells divided into polymorphonuclear, 81 per cent., large mononuclears, 5 per cent.; small mononuclears, 14 per cent. February 10, a suprapubic puncture was performed.

Feb. 11, 1920, the blood nitrogen was 46 mg. per 100 c.c.; February 14, the blood nitrogen was 100 mg. per 100 c.c., and on this date suprapubic drainage was performed; February 17, the blood nitrogen was 150 mg. per 100 c.c.; creatinin, 24. The urine was acid; the specific gravity was 1.022, and it contained neither albumin nor sugar.

*Comment.*—This case shows the postoperative increase in blood nitrogen, which seems to be of rather common occurrence after operative procedures even of simple degree and under local anesthesia.

CASE 12.—C. S. entered Harper Hospital, April 25, 1920, and was discharged, May 20, 1920. He gave a history of prostatic hypertrophy of six years' duration, with more acute symptoms for the last six weeks. The blood pressure was 150 systolic and 90 diastolic. The urine was negative except for a large amount of pus. There was 8 ounces of residual urine.

The blood nitrogen, April 26, was 37.5 mg. per 100 c.c. Suprapubic drainage was instituted April 30. Prostatectomy was performed April 30. Recovery was uneventful.

CASE 13.—J. A. entered Harper Hospital, April 28, 1920, complaining of symptoms of prostatic hypertrophy. There was 250 c.c. of residual urine. The Wassermann reaction was negative. The blood pressure was 120 systolic and 94 diastolic. Blood nitrogen February 28 was 50 mg. per 100 c.c. A one-stage prostatectomy was performed March 1.

Blood nitrogen, March 11, was 75 mg. per 100 c.c., and March 18, it was 36 mg. per 100 c.c. This patient was periodically irrational from March 5 to March 16, 1920. He developed, during this time, a right epididymitis, which was opened and drained.

*Comment.*—Again we have an illustration of the extra injury to the kidney following operation per se as is shown by the increase in blood nitrogen from 50 to 75 mg.

CASE 14.—Mr. S. entered Harper Hospital, May 12, 1920, and died June 10, 1920. He gave a history of hypertrophy of the prostate, with increasing difficulty of urination for ten years. Catheterization was necessary four days before admission. Blood pressure was 130 systolic and 90 diastolic. Suprapubic drainage was performed May 13.

Urine examination, May 14, revealed cloudy acid urine of 1.020 specific gravity. Tests for acetone and diacetic acid were negative. Three subsequent examinations revealed a trace of albumin, and the presence of red blood cells. Otherwise, the urine was negative. Blood nitrogen, May 18, 1920, was 160 mg. per 100 c.c.; May 19, 170 mg. per 100 c.c.; May 21, 170 mg. per 100 c.c.; May 22, 120 mg. per 100 c.c.; May 25, 100 mg. per 100 c.c., and May 28, 66 mg. per 100 c.c. No further examinations were made; but in spite of the apparent decrease, the patient died June 10, 1920, the cause of death being given as uremia.

#### GROUP IV.—GASTRO-INTESTINAL CASES

CASE 15.—C. M., woman, entered Harper Hospital, March 17, 1920, and died March 29, 1920. Operation was performed March 18. Findings were: ulcer of the pylorus and chronic appendicitis. A posterior gastro-enterostomy and appendectomy were performed.

March 18, after anesthesia, the patient vomited three times, the amounts recorded being 3, 4 and 12 ounces. The temperature ranged from 99 to 101.6 F. The pulse varied between 60 and 68. March 19, the patient vomited twice, 6 and 4 ounces. The temperature ran between 101 and 103.4 F.; the pulse between 72 and 100. March 20, no vomiting was recorded. Blood nitrogen determination taken at this time gave 109 mg. per 100 c.c. The temperature ranged between 101 and 102 F.; the pulse from 76 to 80. March 21, there was no vomiting. The temperature ranged from 101.2 to 104 F.; the pulse from 102 to 112. March 22, there was no vomiting; the temperature ranged between 100.8 F. and 103 F.; the pulse from 84 to 96.

No further vomiting was noted on the chart, except a small amount once, March 27. A blood culture taken six hours before death, March 29, gave a growth of pure streptococcus.

Pneumonia was diagnosed, March 22, moist râles being noted. March 24, dulness and bronchial breathing were manifest. Fluid was also suspected, and 160 c.c. was removed from the pleural cavity. The right chest again yielded 600 c.c., March 25, and a roentgenogram, March 29, showed complete consolidation of the right side.

*Comment.*—Unfortunately, no postmortem examination was made, and but one blood nitrogen estimation was obtained. However, we note here a case

in which high obstruction was suspected, and vomiting of slight degree had been present for three days. However, subsequent events proved no obstruction to be present, but possibly a temporary gastric paresis. The blood nitrogen at this period was increased to 109 mg. per 100 c.c.

CASE 16.—Mrs. B. entered Harper Hospital, June 29, 1920, and was discharged, July 21, 1920. Operation was performed June 30. The findings were: pericholecystitis with adhesions around the pylorus and the first portion of the duodenum. A posterior gastro-enterostomy was performed.

The day of the operation the patient vomited ten times, the amounts being small, registering between 1 and 3 ounces. July 1, the patient did not vomit. July 2, she vomited nine times, the amounts being between  $\frac{1}{2}$  and 3 ounces. A blood nitrogen estimation was made on this date, the reading being 28 mg. per 100 c.c. The blood pressure was 152 systolic and 65 diastolic. July 3, the patient vomited three times, the amounts being from 2 to 4 ounces. July 4, she vomited once, the amount being 5 ounces; July 5, eight times, with amounts from  $\frac{1}{2}$  to 10 ounces. A second blood nitrogen was recorded at this time, the amount being 24 mg. per 100 c.c. July 6, the patient vomited once, the amount being 3 ounces.

July 7, a rather profuse brownish purulent drainage appeared. After which the patient's condition improved immediately. No further gastric disturbances were noted, except that, July 13, the patient vomited three times, from 2 to 3 ounces. She was discharged in good condition July 21.

*Comment.*—We have here a case in which obstruction was suspected because of persistent vomiting. That such was not the case is shown by the subsequent history, the gastric irritation having probably been the result of intraperitoneal hemorrhage associated with a low grade of infection. The blood nitrogen was low at both examinations, and the stomach showed no evidence of over filling as would be found in mechanical obstruction, inasmuch as the amount expelled at any one time was always small.

CASE 17.—Mrs. L. P. entered Harper Hospital, April 18, 1920, and died May 17, 1920. This patient was operated on April 20. The findings were recorded as follows: stomach, transverse colon and small bowel bound together with firm adhesions; the omentum was bound down in such a way that it was difficult to deliver the posterior surface of the stomach. Treatment, however, was posterior gastro-enterostomy.

April 21, the patient vomited twice, 3 ounces each time. April 22, she vomited once, 2 ounces, and gastric lavage yielded 10 ounces. April 23, the patient vomited three times, 2, 2 and 3 ounces. The stomach tube, however, yielded 32 ounces. April 24, no vomiting was registered. April 25, one vomiting spell was noted, the amount being 6 ounces. Gastric lavage yielded 16 ounces. April 26, she vomited once, a small amount. April 28, the patient vomited  $\frac{1}{2}$  ounce and the tube yielded 10 ounces. April 29, two vomitings are registered, the amounts being 2 and 60 ounces. April 30, the stomach tube was inserted twice, 35 and 15 ounces being obtained. May 1, she vomited once, 2 ounces; May 2, she vomited once, 3 ounces; but the stomach tube yielded 34 and 15 ounces in two pumpings. May 3, she vomited once, the record being a small amount—the tube gave 9 ounces. May 5, the patient vomited small amounts twice; May 6, twice, 5 and 34 ounces; May 7, three times, 1, 52, and a small amount; May 8, three times, 2, 39 and 1 ounce; May 9, three times, 52, and 28 ounces.

At this time roentgen-ray study was made, which showed an evident duodenal obstruction. A five hour plate showed practically the entire meal retained

in the stomach, and the report made was lower duodenal obstruction. May 10, the patient vomited small amounts, not more than 2 ounces, twice; May 11, five times, from 1 to 4 ounces; May 13, once, 22 ounces.

A blood nitrogen estimation made April 30, ten days after the beginning of obstructive symptoms, gave 50 mg. per 100 c.c. A second estimation, May 13, twenty-one days after obstructive symptoms, gave 33.3 mg. per 100 c.c., which might be classed as normal.

May 14, the abdomen was opened, the obstruction relieved and the posterior gastro-enterostomy undone. The patient died May 17.

*Comment.*—We have here a case of definite proved obstruction at the level of the duodenum, in which blood nitrogen readings were not increased. We would conclude from this case that a small amount of jejunum must be above the obstructive lesion before an increase in blood nitrogen can be noted. The only other alternative is that the obstruction was intermittent in character.

CASE 18.—W. P. entered June 27, 1920, and was operated on, June 28, 1920. The finding was duodenal ulcer. A posterior gastro-enterostomy was performed. June 30, this patient vomited seven times, the amounts not being recorded. July 4, one attack of vomiting is registered, the amount being 6 ounces. July 7, the patient vomited 12 ounces; July 10, a "large amount" is given, and July 11, he vomited twice, and the stomach was twice emptied by means of a tube. No accurate vomitus record was made, but roentgen-ray examination, July 16, revealed practically complete gastric retention at the end of twenty-four hours.

The blood nitrogen, July 12, after four days of vomiting, was 46 mg. per 100 c.c. The blood pressure was 95 systolic and 60 diastolic.

July 19, the abdomen was reopened and an acute kink in the efferent loop was discovered, which was caused by omental adhesions to the abdominal wound. The patient died July 21.

*Comment.*—Again we have a case in which the obstruction was evidently highly situated without an increase in the noncoagulable nitrogen resulting.

CASE 19.—Mrs. G. B. entered Aug. 10, 1920. This patient had been operated on in May, 1920, for a pelvic abscess, which had been drained. She now complained of epigastric pain and nausea. Laparotomy was performed August 11, the finding being charted as a pericholecystitis, with a partial obstruction of the second portion of the duodenum. The adhesions causing this were severed, infolded and so sutured as to relieve the obstruction.

Postanesthetic vomiting was represented by four attacks, each being of a small amount. August 12, the patient vomited eight times, the amount ranging from a small amount to 6 ounces. August 13, she vomited five times, amounts varying from 3 to 19 ounces. She was also disturbed by hiccupping. August 14, she vomited twice, the amounts being  $\frac{1}{2}$  and 2 ounces.

A blood nitrogen estimation at this time gave 41.5 mg. per 100 c.c.

August 15, two attacks of vomiting were noted, a small amount and 5 ounces. August 17, she vomited once, 8 ounces. August 21, she vomited once. Recovery was uneventful thereafter.

*Comment.*—This represents a case in which the operator evidently suspected high obstruction, which was neither borne out by the nitrogen reading nor by the subsequent history.

CASE 20.—Mr. H. entered Harper Hospital, Oct. 5, 1920, and was discharged, Nov. 10, 1920. A posterior gastro-enterostomy and an appendectomy were performed October 13. The findings were: duodenal ulcer and chronic appendicitis. The ulcer was on the posterior wall of the duodenum just below the pylorus. There were numerous adhesions between the omentum, duodenum and gallbladder. Postanesthetic vomiting consisted of 3 ounces at one period, October 13.

The patient progressed favorably until October 21, when he vomited twice. The register states that the first was a large amount, the second 32 ounces. October 22, the patient vomited four times, 30, 18, 12 and 30 ounces. October 23, two vomiting periods were noted, 32 and 18 ounces. October 24, the patient vomited five times, the amounts being 23, 3, 7, 16 and 12 ounces. The abdomen was re-opened at 8:00 p. m. that night.

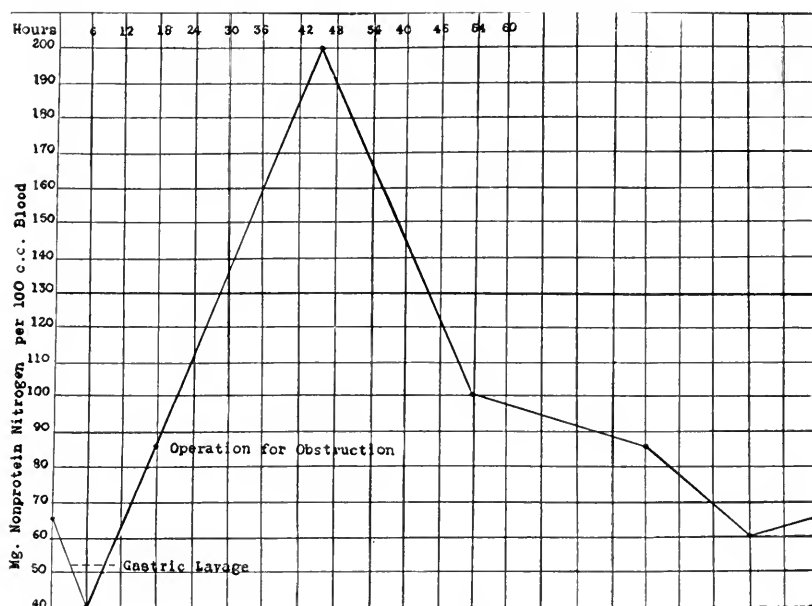


Fig. 1 (Case 20).—Increase in blood nonprotein nitrogen in a case of high obstruction.

Blood nitrogen estimations were commenced at 10:15 a. m. October 23, and the first reading showed 67 mg. per 100 c.c.; at 4:15 p. m. of the same date 40 mg. per 100 c.c. were noted. Gastric lavage had been given between.

October 24, at 11:45 a. m. the blood nitrogen was 86 mg. per 100 c.c. and, as stated above, the patient was re-operated on at 8:00 p. m. that evening. The second operation disclosed an omental adhesion to the anterior abdominal wall along the previously made incision. After dividing these adhesions, the duodenum was exposed and the jejunum was found to be distended for a distance of 18 inches below the gastro-enterostomy. At this point the intestine was collapsed, a definite ring being found at the collapsed point. The ring had evidently been caused by the adhesions which had been freed. The jejunum filled into the collapsed part while under observation. The wound was closed.

The next day, October 25, gastric lavage yielded 26 ounces. There was no more vomiting except once, October 27, the amount being 30 ounces. The further recovery was uneventful and the patient when seen, December 10, reported a gain of 30 pounds, with no gastric symptoms.

Further blood nitrogen estimations made after the second operation proved of interest: 2 p. m., Oct. 25, 1920, gave 200 mg. per 100 c.c.; October 26, 100 mg. were reported; October 27, 86 mg. were present; 9 a. m., October 28, the amount was 60 mg., and October 30, 67 mg. per 100 c.c. were recorded.

Thus we can see that the nonprotein blood nitrogen showed a decided increase after the obstruction had been relieved, and that more than forty-eight hours elapsed before the percentage had receded to a point equal to what it was before the second operation was performed.

*Comment.*—This case shows the blood nitrogen increase noted in a high obstruction situated 18 inches below Treitz's ligament. It differs from Cases 15 and 16 in that a short portion of the absorptive jejunum was above the obstruction. It also illustrates the necessity of performing repeated examinations, and drawing conclusions from the upward trend of the nonprotein blood nitrogen. Placing reliance upon a single reading is likely to be unreliable. For this reason a curve of the increase has been made in this case (Chart 1).

CASE 21.—Mr. L. entered Harper Hospital, Nov. 23 and died Nov. 30, 1920. The diagnosis upon entrance was carcinoma of the rectosigmoidal juncture, with obstructive symptoms. Operation was performed under local anesthesia, November 24. This consisted solely in preparing the transverse colon for a colostomy. Examination of the liver at this time showed that metastasis was present. November 26, the colostomy was opened. This apparently never functioned. Content of the large intestine could be washed up from below, but no fecal matter could be washed from above. Symptoms of obstruction continued until death, which occurred at 10:45 p. m. November 30.

The first blood nitrogen estimation was obtained at 9 a. m., November 29. It gave: 86 mg. per 100 c.c.; at 6 p. m. the same date 74.2 mg. per 100 c.c. were noted. At 2:00 p. m., the date of death, 100 mg. per 100 c.c. were obtained.

In view of the continued increasing blood nitrogen curve, the postmortem findings are of interest.

The abdominal cavity contained neither fluid nor gas. The intestines and stomach were markedly distended. At the juncture of the sigmoid and rectum there was a large mass about 4 by 4 by 4 inches. This was firmly adherent to the bladder anteriorly, while posteriorly it was attached to the tissues over the sacrum. It did not involve any other portion of the large intestine. The descending colon was filled with impacted feces. The colostomy opening was situated at the midportion of the transverse colon. In the appendix area there were found a number of adhesions, one of which involved the cecum, and fastened it to the abdominal wall about the midaxillary line, and 2 cm. above the crest of the ileum. This caused an acute kink in the intestine, above which point the intestines were found to be distended. Below this point there was no distention. About one half of the appendix was found to be present. No other findings of importance were noted, except the liver metastasis previously noted, and an involvement of the retroperitoneal lymph glands. Microscopic findings confirmed the diagnosis of adenocarcinoma with metastasis.

*Comment.*—This case is interesting because of the fact that a partial obstruction caused by tumor growth was evidently changed into a complete obstruction caused by a twisting of the intestine at the site of adhesions following an old appendicitis. The terminal obstruction situated at the ileocecal valve was

above the colostomy opening. The entire length of the small intestine was above this lesion. Along with these findings we have a progressively increasing blood nitrogen curve. The reading, however, did not reach as high a level as in many other cases, being only 100 mg. per 100 c.c. a few hours before death.

CASE 22.—Mr. J. S. was admitted to Harper Hospital November 6, and died Nov. 9, 1920. On entering the hospital this patient gave a history of persistent vomiting together with no bowel movement for a period of eight days. The abdomen was noticeably distended, and the patient was markedly dehydrated. He stated that he had had to use a laxative nightly for the last nine or ten years. Vomiting began October 29. There was a decided odor of acetone in the expired air. The temperature was 98 F., and the pulse 100. The diagnosis was intestinal obstruction.

November 6, the date of entrance, the abdomen was opened through a right gridiron incision. The small bowel was markedly distended, the terminal ileum was brought out and an enterostomy performed. Blood nitrogen taken upon this date, November 6, gave 240 mg. per 100 c.c. The patient continued to vomit and received no benefit. The blood nitrogen, November 8, was 300 mg. per 100 c.c. The patient died the next day.

Postmortem findings showed the omentum and intestine to be adherent around the enterostomy opening. There was no free fluid in the abdomen. Upon separating the omentum from the coils of the intestine, an acute angulation of the ileum was found at the enterostomy wound. The proximal loop of the intestine was turned sharply downward completely shutting off its lumen, and was filled with a large quantity of fluid and gas. The portion of the proximal loop immediately adjacent to the enterostomy wound was entirely in the pelvis and dragged down upon the enterostomy keeping it tightly closed. The tube, which had been inserted into the lumen of the intestine was in the distal and not in the proximal intestine. About 12 inches proximal to the ileocecal valve was found the original site of the organic obstruction. The body of the appendix was over the pelvic brim and reached well down into the pelvis where it was adherent by many old adhesions to a tangled mass of ileum and sigmoid. Distal to this the intestine was collapsed, while in a proximal direction it was hugely dilated and filled with fluid. Otherwise, the abdomen was negative.

*Comment.*—Again we have the attempted relief of a bowel obstruction, followed immediately by a more complete obstruction. The blood nitrogen readings again show an increase, the total being much higher than in the previous case.

CASE 23.—Mrs. W. entered the Harper Hospital February 27, and died March 19, 1920. March 3, an operation was performed for the relief of a postoperative ventral hernia. This consisted of dissecting free adherent bowel in a large sac, and it was deemed necessary to resect the small intestine for a distance of 1 foot. An end-to-end anastomosis was performed.

March 13, the patient vomited once, the amount being 3 ounces. The temperature reached 104.2 F., the pulse 104 and respiration 22. No more vomiting was noted until March 17. The temperature ranged from 100 to 106 F., the pulse from 102 to 124. March 17, the patient vomited twice, at 4:45 p. m., 2 ounces; at 9:00 p. m., a small amount.

The blood nitrogen at 12:15 p. m., March 17, was 150 mg. per 100 c.c. At 7:20 p. m. it read 171 mg., and at 10 a. m., March 18, it registered 184 mg. per 100 c.c. The question was one of infection or obstruction. Vomiting had been small in amount.

March 17, at 10 p. m. the abdomen was reopened. The small bowel was found to be dilated to 3 inches. Tubes were inserted at two levels and fluid and gas evacuated. The patient died March 19 at 1 p. m.

No postmortem was made, but the secondary operative findings bore out the supposition of small intestine obstruction.

CASE 24.—Mrs. E. entered Harper Hospital, May 17 and was discharged June 19, 1920. May 18, operation consisting of the removal of internal and external hemorrhoids, dilatation and curettage, appendectomy, partial excision of the right ovary, left oophorectomy and shortening of the round ligaments, was performed.

Postanesthetic vomiting, May 18, consisted of 5 ounces, accomplished in one period. May 19, the patient belched considerable gas. The temperature average was 99.8 F., the pulse 112. Blood pressure was 135 systolic and 85 diastolic. She vomited once, the amount being 5 ounces. An enema was effectual for gas and a small amount of clear fluid.

The blood nitrogen at this time, taken at 2 p. m., gave 75 mg. per 100 c.c.

May 20, the belching of gas and abdominal pain continued. No further vomiting was registered, and May 21, a small bowel movement was recorded, and the patient progressed favorably thereafter. The blood nitrogen, May 21, registered 27 mg. per 100 c.c.

*Comment.*—In this case there was some degree of gastric and intestinal paralysis from which the patient quickly recovered. Here we note a decided increase in the blood nitrogen estimation, which was quickly followed by a decrease.

CASE 25.—Mrs. F. entered Harper Hospital, June 27, 1920. June 28, a pan-hysterectomy was performed with the removal of the upper portion of the vagina and a section of bladder for carcinoma. Gallstones were noted, but not disturbed because of the amount of work performed.

June 28, the temperature ranged from 98 to 101.2 F., the pulse from 80 to 116. June 29, the temperature ranged from 100.4 to 101.8 F., the pulse from 116 to 128. Abdominal distention was marked, and an enema furnished no results.

June 30, the temperature ranged from 99 to 99.4 F., the pulse from 104 to 128. The patient was markedly distended and vomited twice, the amount being  $\frac{1}{2}$  ounce each time. Four enemas were given and five injections of pituitary extract without effect until that night when considerable flatus was expelled.

The blood nitrogen at 10:20 a. m., June 30, was 100 mg. per 100 c.c. At 2 p. m. it was again 100, and at 9 p. m. it registered 133 mg. per 100 c.c. July 1, the temperature ranged from 98.8 to 100.2 F., the pulse from 112 to 128. She vomited twice in amounts of 3 ounces and  $\frac{1}{2}$  ounce. Gastric lavage yielded 12 ounces. No result was obtained by means of an enema. A blood nitrogen taken at 11 a. m., however, showed a decrease to 67 mg. per 100 c.c. July 2, the temperature ranged from 98.2 to 98.8 F., the pulse from 108 to 116. The stomach tube yielded only 1 ounce. Two enemas were slightly effectual. After this, recovery was uneventful. Blood nitrogen, July 5, was 60 mg. per 100 c.c. The patient was discharged in good condition, July 15, 1920.

*Comment.*—We note here another case of rather severe intestinal paresis accompanied by a high blood nitrogen reading. One case, as cited above, of complete fatal obstruction did not give as high a reading as is noted here. However, a downward drop of 66 mg. was here noted in fourteen hours, which in our opinion classified this case as intestinal paresis instead of true obstruction.



CASE 26.—Miss H. N. entered, July 20, 1920, with a diagnosis of gangrenous appendicitis. Blood count revealed: leukocytes, 13,000; differential: polymorphonuclears, 85 per cent.; small mononuclears, 6 per cent.; large mononuclears 9 per cent. The temperature was 101 F., the pulse 96 at the time of entrance. A gangrenous appendix was removed July 20, and the wound closed tight. July 21, the patient vomited twice, the amount each time being 4 ounces. Gastric lavage gave a light green return, the amount not being registered. There was marked distention. The temperature varied between 100.2 and 101.4 F., the pulse between 96 and 156.

July 22, she vomited small amounts twice. Lavage gave a dark brown return. The blood pressure was 116 systolic and 85 diastolic. The lowest temperature was 101, the highest 102.8 F., while the pulse ranged around 150. She died at 11:30 p. m. The nonprotein nitrogen estimated upon the date of death showed 67 mg. per 100 c.c. The cause of death was evidently an overwhelming infection.

*Comment.*—This represents a case of severe sepsis in which there was some degree of intestinal paralysis. The blood nitrogen reading was somewhat increased, which agrees with our findings in other cases.

CASE 27.—T. S. entered Harper Hospital, April 9, 1920, complaining of pain and tenderness in the lower abdomen. The pulse was 96, the temperature 99 F. The total leukocyte count gave 21,000, of which 95 per cent. were polymorphonuclears. The operative findings were seropurulent fluid in free cavity, and a perforated gangrenous appendix. This was removed and drainage inserted. Recovery was uneventful.

Nonprotein blood nitrogen obtained, April 10, the day after operation, showed 35 mg. per 100 c.c. The urine showed a trace of albumin, but otherwise it was negative.

*Comment.*—This is a second case of general peritonitis following a gangrenous appendix, which differed from the previous in the practical absence of any gastro-intestinal symptoms. Here the blood nitrogen reading might be classed as normal.

CASE 27.—W. W. entered, May 10, 1920. The diagnosis was gangrenous appendicitis with general peritonitis. Operative findings were: purulent fluid free in peritoneal cavity, 3½-inch retrocecal appendix, gangrenous at distal end with a perforation one half inch from the tip. Appendectomy with drainage was performed. Daily after operation the patient had one or more vomiting spells of small amount. There was considerable distention and pain. On the thirteenth day after operation, a blood nitrogen reading gave 22 mg. per 100 c.c. Enemas and cathartics were but slightly effectual for feces and flatus. May 29, the wound was reopened and a large walled off abscess was found in the rectal fossa. This was drained and recovery was uneventful thereafter.

*Comment.*—This was a case of possible obstruction, not borne out by the blood nitrogen findings, which proved to be not obstructive, but abscess formation.

CASE 28.—Mrs. M. entered Harper Hospital, May 2, and died May 30, 1920. She was operated on, May 26, the operation consisting in the removal of a large intraligamentous leiomyofibroma of the left side. It measured approximately 9 by 4 by 5 inches.

May 26, she vomited once, the amount being 4 ounces. May 27, hiccups were noted, but no vomiting. May 28, the stomach was emptied twice, and an enema was effectual for flatus and light brown fluid. A second enema was not

effectual. The temperature ranged from 100.8 to 103.6 F.; the pulse from 81 to 128. May 29, gastric lavage was repeated. An enema was followed by some flatus with shreds of mucus and a few particles of feces. The stomach was washed a second time and castor oil administered through the tube. A second enema gave no results, but shortly afterward two bowel movements, consisting of a large amount of feces and flatus, were noted. The temperature ranged from 103.8 to 105.8 F., the pulse from 93 to 130. The blood nitrogen taken at 11 a. m. gave 60 mg. per 100 c.c.; repeated at 9:30 a. m. the next morning, May 30, the reading was 66 mg. per 100 c.c. The patient died at 2:30 p. m., May 30.

*Comment.*—No postmortem was obtained, but the fact that good bowel movements were obtained after the administration of castor oil would lead us to interpret this case as one of sepsis in which there was some degree of intestinal paralysis. The blood nitrogen increase would accord with this.

CASE 29.—Mrs. S. entered Harper Hospital, June 29, 1920. The diagnosis was strangulated left femoral hernia, vomiting, pain and irreducible tumor of twenty-five hours' duration. Blood pressure was 140 systolic and 90 diastolic. Blood nitrogen 24 mg. per 100 c.c. Operative findings were: a large sac with a small neck containing strangulated omentum, which was discolored and excised. Search disclosed a discolored loop of small bowel about 5 inches in length, which had slipped back into the abdominal cavity when the sac was opened. This recovered its appearance within two minutes and was replaced.

*Comment.*—This represents a case of strangulated hernia showing no increase in blood nitrogen. Not having seen this case ourselves, it is difficult of interpretation. If the symptoms were caused by strangulated omentum alone, the findings would have been in accord with our other experiences; but if actual intestinal obstruction existed, the low nitrogen is difficult of interpretation. However, it is more than probable that the bowel above the small strangulated area was not dilated to any degree as such should have been noted in the chart if it had been the case. It is to be hoped that the findings in another similar case entering the hospital will be recorded more minutely, and that more nitrogen estimations will be made.

CASE 30.—B. R. entered Harper Hospital, August 6, and was discharged Aug. 25, 1920. The diagnosis was strangulated right inguinal hernia. Pain and vomiting began two days before. Attempts at reduction had failed.

Operation was performed August 7, and a nonprotein blood nitrogen estimation was made the same day. This registered 86 mg. per 100 c.c. The operative findings were: some free fluid in the abdominal cavity with a loop of small bowel in the right inguinal ring. Release of this loop was followed by bowel recovery.

The patient vomited twice August 8, after which recovery was uneventful.

*Comment.*—Strangulated bowel hernia of forty-eight hours' duration was followed by a decided increase in nonprotein blood nitrogen.

CASE 31.—Mrs. H. P. entered Harper Hospital, May 28, 1920. May 29, an appendectomy, left salpingo-oophorectomy, excision and invagination of Meckel's diverticulum were performed. Proctoceles were repaired with reconstruction of the sphincter muscle.

May 30 the temperature registered between 99.2 and 100 F., with a pulse rate between 96 and 120. May 31, the temperature was between 98.6 and 100 F., with a pulse rate of 100 to 122. There was considerable nausea and vomiting.

June 1, blood nitrogen was 20 mg. per 100 c.c.; June 2, it was 17 mg. per 100 c.c.

The patient showed improvement June 1. No more nausea or vomiting were recorded, and she was discharged June 11, 1920.

*Comment.*—This was a case in which the possibility of an obstruction was entertained owing to the clinical symptoms. It was borne out neither by the blood nitrogen finding nor by the subsequent history.

CASE 32.—Mrs. A. entered Harper Hospital, May 17, and was discharged June 9, 1920. May 10, a right salpingo-oophorectomy, left salpingo-oophorectomy, supravaginal hysterectomy because of right tubo-ovarian abscess, multiple myoma of uterus, left hydrosalpinx and cystic left ovary surrounded by dense adhesions, were performed.

May 10 postanesthetic vomiting was registered six times, varying in amount from 1 to 5 ounces. The temperature ranged from 97 to 100.2 F., the pulse from 90 to 118.

There was no vomiting the second day. May 11, the temperature ranged from 98.4 to 99.4 F., the pulse varied between 118 and 120. May 12, the patient was nauseated, but she did not vomit. Temperature varied from 97.4 to 99.2 F., the pulse between 100 and 112.

May 13, she vomited once, amount 2 ounces. Temperature varied from 98.6 to 100.2 F., the pulse from 96 to 100. May 14, there was no vomiting. May 15, she vomited once, 4 ounces. May 16 she was nauseated, but did not vomit. May 17, she was nauseated, vomited once, a small amount. May 18, she was nauseated, vomited once, small amount; May 19, nauseated, vomited three times, 7 to 10 ounces. May 20, she vomited twice, small amounts. May 21, there was no vomiting. May 22, she vomited three times, small amount to 8 ounces. May 23, she vomited eight times, 1 to 8 ounces. May 24, she again vomited eight times, small amounts; gastric lavage was instituted. May 25, she vomited twice, 2 ounces.

Blood nitrogen taken at this date showed 42 mg. per 100 c.c. After this she vomited once, May 30, amount 7 ounces, after which recovery was uneventful.

*Comment.*—After fifteen days of gastric distress, a blood nitrogen estimation showed that no obstruction was present. This was confirmed by the subsequent history.

CASE 33.—Mrs. S. M., colored, aged 26, entered Harper Hospital, Dec. 7, 1920. She was operated on December 10. The findings were: retrocecal appendix, retroverted uterus, small tumor mass 2 cm. in diameter on right uterine cornu and left cystic ovary. The abdomen was otherwise negative. Operative treatment consisted of appendectomy, removal of a tumor on the uterine cornu, and reduplication of round ligaments.

The postoperative course showed nothing unusual until the third day, when the pulse rate increased to between 112 and 128, with normal temperature. The patient vomited once, 10 ounces, the vomitus consisting of a foul, greenish brown fluid. Gastric lavage was performed once—amount not noted. December 13, the fourth day after operation, gastric lavage was performed twice. The pulse ranged from 100 to 122, the temperature was normal. An alum enema was unsuccessful.

December 14, the pulse varied between 96 and 112, the temperature rate between 96 and 101 F. Three enemas were given, two of which were effectual for flatus. No vomiting was recorded. However, the patient was extremely restless. She was distended, and her condition generally was unsatisfactory.

December 15, the first blood nitrogen was recorded. This showed 133 mg. per 100 c.c. The blood pressure was 108 systolic and 78 diastolic, and a total and differential leukocyte count was normal. No further vomiting had been recorded; but the abdomen remained distended and firm in spite of the fact that small amounts of flatus had been expelled. Because of the high blood nitrogen reading, together with the clinical picture presented, the patient was taken to the operating room, and a second laparotomy performed. A right rectus incision was made. There was a moderate amount of serous fluid free in the cavity. The small bowel was markedly distended and dark blue in color. A definite band was found to encircle the ileum near the ileocecal valve. Separation of this was followed by the passage of gas and fluid into the distal portion of the bowel. An enterostomy was performed just above the obstructive area in the ileum.

No more vomiting was recorded until December 23 when the patient vomited once,  $\frac{1}{2}$  ounce. Here, December 26, a notation says, "very little fecal matter drains through the enterostomy now," and evidently another obstructive lesion was feared. December 25, she vomited once, 6 ounces. December 27, she vomited twice, 6 and 2 ounces, and Jan. 1, 1921, once, immediately after partaking of breakfast. Death ensued at 6.55 p. m. January 1.

While the patient's condition was bad almost continually following the operation for obstruction necessitating frequent resort to hypodermoclysis, yet improvement was marked so far as the obstructive symptoms manifested. The enterostomy worked freely and the abdomen was much softer and less distended within twenty-four hours.

December 18 it was noted that the general condition was much improved. Again the chart states, December 19, that the condition was improved, as was also borne out by the pulse rate and temperature.

December 26, the wound opened, exposing about 3 feet of small intestine. In this area three small holes, about 1 cm. in diameter, were noted. As stated above, another obstructive lesion was feared at this time. Together with this possibility, was now a picture of sepsis.

Of chief interest to us, however, is the blood nitrogen curve during and following the obstructive lesion. As stated above, December 15, at 11:45 a. m., the date of the second operation, which occurred at 12 midday, 133 mg. per 100 c.c. were recorded; December 15, at 4 p. m., 130 mg. per 100 c.c.; December 16, at 2 p. m., 75 mg. per 100 c.c.; December 17, at 1 p. m., 32.5 mg. per 100 c.c.; December 17, at 11 p. m., 30 mg. per 100 c.c.; December 18, at 9 a. m., 26 mg. per 100 c.c.; December 23, at 9 a. m., the day that vomiting recurred, 100 mg. per 100 c.c.

*Comment.*—In this case we note an immediate fall in the blood nitrogen reading following the relief of an obstructive lesion. This does not accord with our findings in other cases, notably in Case 20, in which there was a temporary high increase in blood nitrogen following relief of obstruction.

#### CONCLUSIONS

A study of the series of cases noted above leads to certain more or less definite conclusions. Many other cases have been recorded since this tabulation was made, but a review of the latter cases does not alter in any way the conclusions that have been drawn; therefore, a further addition of case reports would be valueless.

In general, it can be stated that a low blood nitrogen in prostatic obstruction may be used as a guide as to the advisability of a one-stage or a two-stage operation. However, other factors than this must be taken into consideration, and it is my belief that the cause of death in many cases, given as uremia following prostatectomy, is erroneous in the extreme, it being due to a low grade infection solely. In corroboration of this point, we cite one more case which was not included in the series heretofore reported:

CASE 34.—Mr. J. P., aged 78 entered Harper Hospital, Dec. 23, 1920, with the diagnosis: hypertrophied prostate with secondary infection. The symptoms were: dribbling, pain on urination, frequent urination, every ten to fifteen minutes, residual urine 250 c.c. Examination revealed a prostate, 4 inches across by  $3\frac{1}{2}$  inches in height—smooth and firm. December 23, suprapubic drainage was instituted under local anesthesia together with a slight amount of gas. A drainage tube 1 inch in diameter was inserted into the bladder. The

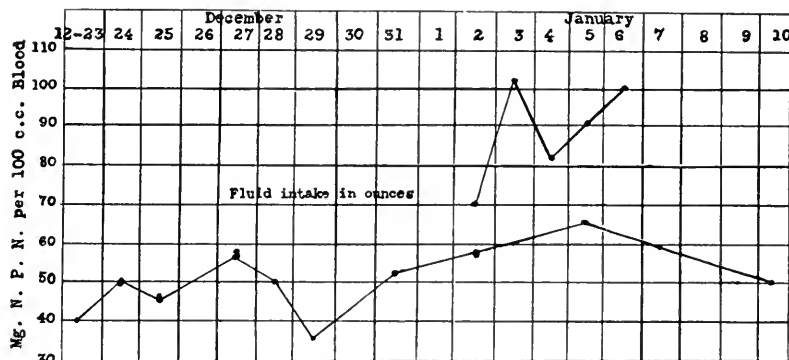


Fig. 2 (Case 34).—Blood nonprotein nitrogen estimations in a case of hypertrophy of the prostate.

postoperative course was unusually stormy. The patient was irrational for many weeks. He was very restless, would attempt to get out of bed and would sleep for periods of from fifteen to thirty minutes at a time.

December 31, he developed a right sided parotitis. After this, his breathing became labored and he slept more or less constantly. The temperature at this time registered as high as 101.6 F.; the pulse 106 and of poor quality. January 3, the patient developed a left parotitis. January 6, this had cleared up and the general condition had improved. He was brighter and had periods when he was more rational. Thus, we had a clinical picture simulating that of uremia, and yet the cause of this syndrome, in our opinion, was solely an infection.

Before operation, Dec. 23, 1920, the blood nitrogen was 40 mg. per 100 c.c.; December 24, it read 50 mg. per 100 c.c.; December 25, 46 mg. per 100 c.c.; December 27, 57 mg. per 100 c.c.; December 28, 50 mg. per 100 c.c.; December 29, 33.4 mg. per 100 c.c.; December 31, 52 mg. per 100 c.c.; January 3, 60 mg. per 100 c.c.; January 5, 67 mg. per 100 c.c., and January 10, 50 mg. per 100 c.c.

Thus, we had a fluctuating blood nitrogen finding which, however, never reached a high level. The patient left the hospital, January 11, and the prostate has subsequently been removed, but his mental condition is even yet far from satisfactory.

A persistent high blood nitrogen estimation is, I believe, a sign of grave prognosis in genito-urinary surgical conditions, but one single high reading is of but little significance. Indeed, a single, or even two or three, estimations, may be of but little value. It is the daily or more frequently estimated curve that is of prognostic value, and any other method of interpretation may lead to erroneous conclusions.

When we come to consider gastro-intestinal lesions, this fact, that conclusions should be drawn, not from a single estimation, but from the curve formed by repeated estimations, is even more forcibly impressed on us.

In postoperative cases we are frequently unable to differentiate between intestinal paresis and true obstruction. Both may have a high blood nitrogen estimation, but the curve goes upward in true obstruction, and tends to fall when such a lesion is not present.

It is my belief that the chief value we have derived from this work is that it has caused us to operate in cases of true intestinal obstruction earlier than we would have otherwise done, thus materially reducing our mortality in this condition. It must be remembered, however, that high duodenal obstruction, above the absorptive area of the intestine, gives no increase in the blood nitrogen estimation even when complete. It is now our practice, when intestinal obstruction below this area is suspected, to have blood nitrogen estimations made from every four to six hours and to place considerable reliance on the curve plotted by these successive readings. If it increases rapidly, the abdomen is immediately opened. If there is no increase, or a decrease is noted, it is safe to temporize.

## FUNCTION IN RELATION TO TRANSPLANTATION OF BONE \*

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During recent years the subject of transplantation of bone has occupied an important place in the literature and has been the text of many practical as well as experimental papers. It is agreed and accepted by the majority of investigators that a live piece of bone from the same individual, with its periosteum and endosteum intact, is the most satisfactory tissue and offers the greatest possibility of successful transplantation. But there are many problems connected with bone transplantation, both from the scientific and the practical standpoint, that are unsolved and disputed. One of these, which will be considered in this paper, is that which is concerned with the part played by function and its influence over the viability of transplanted bone.

If we direct our attention to the physiology of the animal body many instances of the influence of function may be seen. In general, with a maximum of function, there is an increase in size, in strength, in activity and vitality, while with a minimum of function, there is a diminution in size, in strength, in activity and vitality. Thus we see in certain glandular structures, as, for instance, the thymus, a gradual increase in size and activity up to its maximum of function and then a decrease in size to almost complete disappearance with the diminution of function. Again with a more easily comprehensible tissue like muscle, there is the increase in size, strength, activity and vitality with greater use and function of this particular tissue up to the maximum for the individual and a corresponding decrease in these properties with a lessening and minimum of function. In the case of bone, we are not accustomed to associate function so closely with its developmental and growing changes; but by analyzing the various processes, one can see the relationship to the changes in this tissue. Thus, as bone develops from its embryologic structure, either from connective tissue or cartilage, it changes from a soft elastic and pliable tissue to a firm, hard, strong and somewhat brittle substance. This change in structure is coincident with the demands of function, as in the embryo and in early life, the only functional call upon the new cartilaginous tissue is the maintenance of form. As movements become more active and greater strength is required, an osteoid tissue is formed, and finally with the next demand for support, there is need for a stronger tissue and the mineral constituents are added, changing the osteoid to osseous

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tissue. With further elaboration and more localized functional demands at a definite place on a particular bone, there take place, in response to such demand, certain changes within the bone itself, and osseous tissue is deposited or formed at a particular place with such definite mechanical and architectural arrangement as is required best to fulfill such needs. This is best exemplified in the structure of the neck and upper portion of the shaft of the femur, where one sees on cross section a system of girders and trusses so mechanically arranged as to offer the greatest strength to the components of force acting upon this part of the bone. One can also see greater density and thickness of the cortex at the point of greatest strain exerted by muscle tension.

When we come to consider the part played by function in relation to the vitality and increase in size of a bone graft, the problem becomes somewhat more complicated. By analogy it would seem that certain of these physiologic demands should prove to be an influencing factor in the case of the transplanted bone; that is, it would be one of the determining factors in the persistence, the growth and the development of the bone graft. The quantitative rôle played by function has been variously stated by different authors without proof or reason for such assertions. My views on this particular point, as well as on transplanted bone in general, can be best expressed by quoting from a previous article:<sup>1</sup>

From these experiments and the results in general on transplanted bone, the following conclusion is offered regarding the fate of bone transplantation. Although each part of the transplanted bone possesses the power to regenerate independently and without the aid of neighboring bone, this autonomous newly formed tissue does not possess that property which is necessary for a continued existence, and it will ultimately entirely disappear. Some additional stimulus is needed and such conditions are only obtained when the transplanted bone is in contact with normal growing bone. Therefore, when there is failure of such connection the transplanted bone at first shows evidence of regeneration, but if a sufficient time is allowed to elapse, it will ultimately entirely disappear. However, if it is united with the cut surface of normal bone, it will continue to live because certain necessary additional stimuli and new elements will be supplied by the host. It is possible that certain chemical or physiologic stimuli are supplied by the living intact bone after which the regenerated bone on account of these additional factors is able to persist permanently. Undoubtedly, some definite osseous elements from the bone of the host invade the transplant and either replace the temporary bone or give to it certain requisites for its perpetuation. *Although function may play a factor in the development of bone, it is not of prime importance in determining the permanency of that tissue.* The different opinions of the various investigators are in part due to the failure to allow sufficient time to elapse before drawing final conclusions, as well as to take into account the influence of different environmental conditions on the transplant from both young and old animals.

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1. Haas, S. L.: The Transplantation of the Articular End of Bone, Including the Epiphyseal Cartilage Line, Surg., Gynec. & Obst. **23**:301 (Sept.) 1916.



Thus, it is seen that function is considered as playing a very minor part; but such deductions were arrived at more by exclusion than by evidence. It is hoped that the investigation herewith reported will throw some light upon this interesting problem and graphically express the effects of this peculiar force called function.

It is also to be noted that the view is maintained that it is absolutely essential that the transplant be in contact with the freshly cut surface of normal bone in order to be permanently successful. In order to

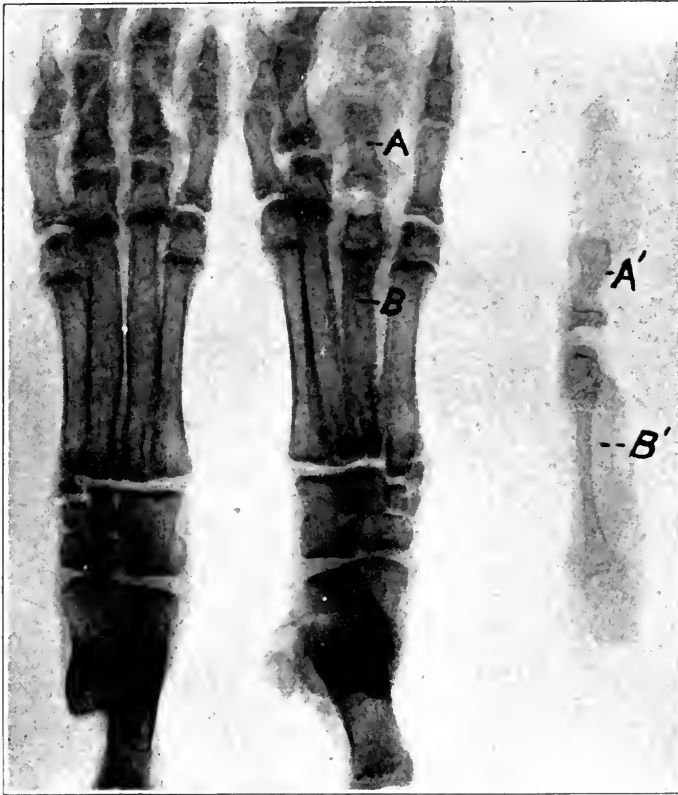


Fig. 1 (Exper. 2, duration fifty-five days, young dog).—*A*, reimplanted phalanx; *B*, reimplanted metatarsal; *A'*, transplanted phalanx, and *B'*, transplanted metatarsal. When the reimplanted phalanx *A* is compared with the transplanted phalanx *A'* that was removed from the muscles of the back at the end of fifty-five days, the transplanted phalanx shows more evidence of degeneration than the reimplanted bone, being less dense, smaller, and more irregular in outline. When the reimplanted metatarsal *B* is compared with the transplanted metatarsal *B'*, the same relative difference between these bones as between the other two is seen. There is an osseous union of the reimplanted with the adjoining bones at the base. The reimplanted bones which are subjected to the normal stimulation of function show less evidence of degeneration than the transplanted bones which are removed from this normal stimulus.

determine the rôle played by function independently of all other factors, it becomes necessary to eliminate the possibility of contact with denuded bone and prevent such stimulating influences as ingrowth of new bone. Thus a set of experiments have been devised which it

is believed offer the conditions necessary to solve this problem. The metacarpal or metatarsal bones are easily manipulated and afford very suitable bones for the purposes of transplantation, but in their removal, the periosteum and cortex as well as the cortex of the neighboring bones are liable to be injured, thereby offering the possibility of ingrowth of bone. The proximal phalanx, however, can be removed quite easily without injuring its periosteum or the adjoining bones, thereby offering no possibility for the ingrowth of bone. It could then be transplanted to the muscles of the back or reimplanted in its original position. In order to insure the possibility of normal function, it is considered as being desirable to preserve the joints at either end and this is accomplished by removing the entire metacarpal or metatarsal bone, the intact joint between it and the first phalanx, and one half of the second phalanx with the intact joint between the two phalanges. In such a transplant, there is an entire first phalanx with both its joints intact and its osseous elements separated at either end by two articular cartilages from the osseous elements of adjoining bones. Furthermore, the adjoining bones are themselves part of the transplant. With such a group forming a transplant, there is practically no chance for ingrowth of bone into the first phalanx unless there is a destruction of the articular cartilage of the phalanx as well as that of the neighboring bones; and as articular cartilage is quite transplantable and does not tend to degenerate, it offers an ideal barrier against ingrowing bone.

If this group of bones be removed from an animal's foot and then reimplanted in the same place, they would be subjected to their normal stimulation of function. If a similar group of bones be transplanted to the muscles of the back, they would not be subjected to the stimulation of normal function. The first phalanges, when compared to each other at the termination of the experiment, would show the influence of function on the graft, because both transplants would have been subjected to the same amount of trauma in their removal, to the same destruction of their blood supply and would differ only in the bed which they occupy and the function to which they are subjected. It is considered that any difference in the two bones can, therefore, be ascribed to the difference in function, and with this for a working basis, the following set of experiments was performed.

#### OPERATIVE PROCEDURE

All of the operations were performed upon dogs of various ages. In every instance a general anesthetic was used and precautions were taken in the after-care to prevent any suffering. The operations were performed with the usual aseptic technic, in this manner. An incision was made on the dorsum of the foot through skin and subcutaneous

tissues so as to expose the metatarsal or metacarpal bones with their corresponding phalanges. The selected bones were carefully removed so as to cause as little trauma as possible and treated according to the plan of the experiment. The wounds were then closed in layers and a sterile dressing applied, which was held in place by adhesive plaster and, when necessary, by a plaster-of-Paris bandage. The animal was allowed to use the foot from the start, and as soon as healing was complete, all dressings were removed. At the conclusion of the experiment, roentgenograms were taken of the feet and the bones that were transplanted to the muscles of the back. In addition to this, pieces of the bones were fixed for microscopic study.

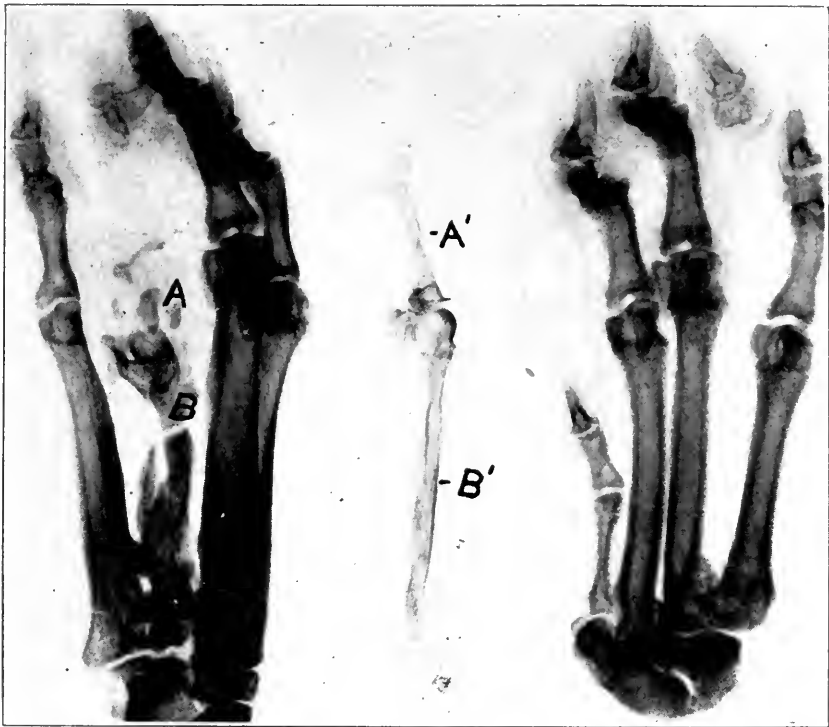


Fig. 2 (Exper. 3, duration sixty-nine days, young animal).—*A* and *B*, infected reimplanted metatarsal and phalanx; *A'*, transplanted phalanx and *B'*, transplanted metacarpal. Because of the infection, the reimplanted bones are unsatisfactory for comparison. The transplanted phalanx *A'*, which was removed from the muscles of the back at the end of sixty-nine days, shows marked absorption thinning, and rarefaction of the cortex. The transplanted metacarpal bone *B'* shows similar changes when compared to the normal phalanx. The destructive processes are more marked than those in the previous experiment (Fig. 1).

#### REPORT OF EXPERIMENTS

EXPERIMENT 1 (Duration, forty-eight days; reference numbers, 50-52, 51-52).—(a) The entire third metacarpal bone of the left fore foot was removed and transplanted to the muscles on the right side of the back.

(b) The entire second metacarpal bone of the fore foot was removed and immediately replaced in its normal position.

## FINDINGS, FORTY-EIGHT DAYS

*Gross.*—(a) The bone was found embedded in the muscles of the back. The epiphyseal cartilage plate is white and quite distinct. The marrow space of the epiphysis is occupied by cancellous bone. The remainder of the marrow cavity is smaller than normal and contains pale marrow. The transplant is smaller than the normal bone and appears to be undergoing atrophic changes.

*Microscopic.*—(a) The articular cartilage is of fairly normal structure. The marrow of the epiphysis is in part replaced by fibrous tissue, the remainder being of fairly normal appearance. The trabeculae of the epiphysis show evidence of degeneration in their centers and regeneration about the periphery. The marrow of the diaphysis is for the greater part replaced by fibrous tissue. The cortex shows some lacunar absorption on its surface which is quite different from the deposition of new bone seen in the case of the normal bone.

*Gross.*—(b) The reimplanted bone appears more like the normal bone than the bone transplanted to the back. The marrow cavity is narrow, and the marrow elements appear paler and less in amount than normal.

*Microscopic.*—(b) The articular cartilage is practically normal. The marrow is for the greater part replaced by fibrous tissue. The trabeculae show degeneration at the center and newly formed bone on the periphery. The marrow of the diaphysis is likewise replaced by fibrous tissue, and the trabeculae show the same changes as in the epiphysis. The cortical bone shows degeneration within its outer layer and a new deposit of bone on the periphery.

## COMMENT

In this experiment, the metacarpal was transplanted alone, and, therefore, the criticism that there is an ingrowth from the neighboring bones may be made. However, the experiment is reported to show the early changes that take place in transplanted bones. There is an early degeneration with a subsequent regeneration of at least a portion of the bone. The bone transplanted to the back shows a more marked degeneration and early evidence of absorption.

EXPERIMENT 2 (Duration, fifty-five days; reference number 132, 80-133, 80, young dog).—(a) The entire fourth metacarpal bone with its adjoining phalanx was removed from the left fore foot and transplanted to the muscles of the back on the right side of the spine.

(b) The entire third metatarsal bone with its adjoining first phalanx and one half of the second phalanx of the right hind foot was removed and replaced in its normal position.

## FINDINGS, FIFTY-FIVE DAYS

*Gross.*—(a) The bones transplanted to the muscles of the back are found encapsulated in dense fibrous tissue. They are much smaller than the normal bones. On longitudinal section, the marrow of the metacarpal is seen to be very scant while that of the phalanx is fairly normal. The roentgenogram (Fig. 1) shows the marked absorption of the metacarpal bone as well as of the phalanx. The joint surfaces appear normal.

*Microscopic.*—(a) The phalanx, on section, shows an almost normal articular cartilage. The marrow elements of the proximal end have been partially replaced by fibrous tissue. The epiphyseal cartilage plate has almost entirely disappeared. The cortex is very thin and irregular showing considerable evidence of erosion and absorption.

*Gross.*—(b) The reimplanted bones are found well healed in their bed. The bones are shorter and broader than the normal bones. On longitudinal section the marrow of the phalanx is found to be practically normal. The metatarsal bone shows marked thickening of the articular cartilage with a widening of the epiphysis. The cancellous bone is of variable color. The epiphyseal cartilage plate is undergoing calcification at its center. The cortex is very thin and irregular showing considerable evidence of erosion and absorption.

The roentgenogram (Fig. 1) shows the transplanted bones shorter than normal. The phalanx is of normal breadth and its structure is normal, except that the marrow space is not so distinct. The metatarsal appears normal and one sees a union with the adjoining bones at the base.

*Microscopic.*—(b) Examination reveals a partial degeneration of the articular cartilage. The marrow elements have been replaced by fibrous tissue. The trabeculae possess well stained nuclei which are larger than normal and have somewhat the appearance of regenerated nuclei. The cortex shows marked signs of degeneration and in places is very thin.

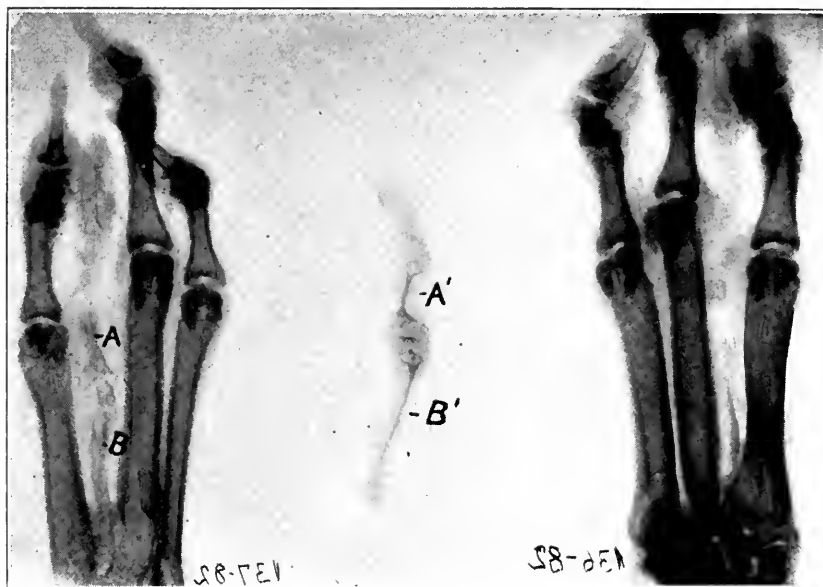


Fig. 3 (Exper. 4, duration 273 days, very young animal).—A, reimplanted phalanx; B, reimplanted metacarpal bone; A', transplanted phalanx, and B', transplanted metacarpal bone removed from muscles of back. There is a marked absorption both in the reimplanted and in the transplanted bones. On close study, the degeneration is found to be greater in the transplanted bone than in the reimplanted bone. This difference is more evident in the gross specimen than in the roentgenogram.

#### COMPARATIVE RESULTS

A comparison of the reimplanted with the transplanted bones reveals evidence of greater absorption and degeneration in the case of the bone transplanted to the back.

EXPERIMENT 3 (Duration, sixty-nine days; reference numbers 146, 87-148, 87).—(a) The entire third metacarpal bone of the left fore foot with its corresponding first phalanx and one half of the second phalanx was removed and reimplanted in its normal position.

(b) The entire fourth metatarsal bone of the right hind foot with its corresponding first phalanx and one half of the second phalanx was removed and reimplanted in its normal position.

#### FINDINGS, SIXTY-NINE DAYS

*Gross.*—(a) The metacarpal bone and phalanx show considerable evidence of atrophy. The cortex of the metacarpal is irregular. The marrow cavity is likewise irregular. The end of the bone is penetrated by fibrous tissue. The phalanx is likewise found to have an irregular cortex and the marrow cavity is almost absent. The roentgenogram (Fig. 2) shows the evidence of absorption with the thinning and atrophy of osseous elements.

*Microscopic.*—(a) This examination was unsatisfactory because of the poor staining. However, one could distinguish the evidence of degeneration and absorption.

*Gross.*—(b) Because of infection with resulting osteomyelitis, the bones were partially destroyed. The results of this experiment are therefore altered. The metacarpal that remains is irregular, but rather eburnated. The phalanx has practically disappeared.

*Microscopic.*—(b) The cortex and trabeculae show poorly stained nuclei while those of the marrow stain fairly well.

EXPERIMENT 4 (Duration, 273 days; reference numbers 136, 82-137, 82, young dog).—(a) The entire metacarpal of the right fore foot with its corresponding first phalanx and one half of the second phalanx was removed and transplanted to the muscles of the back. The periosteum was stripped off the metacarpal.

(b) The entire third metacarpal bone of the left hind foot with the entire first phalanx and one half of the second phalanx was removed. The periosteum was removed from the metatarsal and then the entire specimen was reimplanted in its original position.

#### FINDINGS, TWO HUNDRED AND SEVENTY-THREE DAYS

*Gross.*—(a) The specimen removed from the muscles of the back shows a complete disappearance of one half of the second phalanx. The first phalanx is atrophied to a sliver-like mass and bends like cartilaginous tissue. The metacarpal is likewise atrophied but not to such an extent as the other bones. The roentgenogram (Fig. 3) shows that the phalanx and metacarpal bone have undergone atrophy. When compared with the reimplanted bones, the atrophy is found to be greater than that which has occurred in those bones.

*Microscopic.*—(a) The transplanted bone shows an extensive degeneration throughout the various parts of the articular cartilage. There are in places clusters of cells suggesting an attempt at regeneration. The marrow has been replaced by fatty tissue which is quite vascular. The osseous tissue has lost the greater part of its nuclear staining and everywhere shows evidence of degeneration.

*Gross.*—(b) The reimplanted bones show marked evidence of atrophy but not to the extent of the bones that were transplanted to the back. The joints are partially destroyed. The roentgenogram (Fig. 3) shows the absorption of the bones, which when compared with the bones transplanted to the back is less marked. The joints appear quite indistinct.

*Microscopic.*—(b) There is degeneration of the articular cartilage but of a lesser degree than in the case of the transplanted bones. The marrow is replaced by fibrous and fatty tissue. The osseous tissue is undergoing degen-

eration as evidenced by the poor staining of the nuclei. In places the nuclei stain fairly well, showing that the degeneration is not so complete as in the case of the bone transplanted to the back.

EXPERIMENT 5 (Duration, 493 days; reference numbers 141, 84-143, 84, old dog).—(a) The entire fourth metacarpal bone of the left fore foot with its corresponding first phalanx and one half of the second phalanx was removed and the entire specimen transplanted to the muscles along the left side of the spine.

(b) The entire fourth metatarsal bone of the right hind foot with its corresponding first phalanx and one half of the second phalanx was removed and the entire mass reimplanted in its original position.

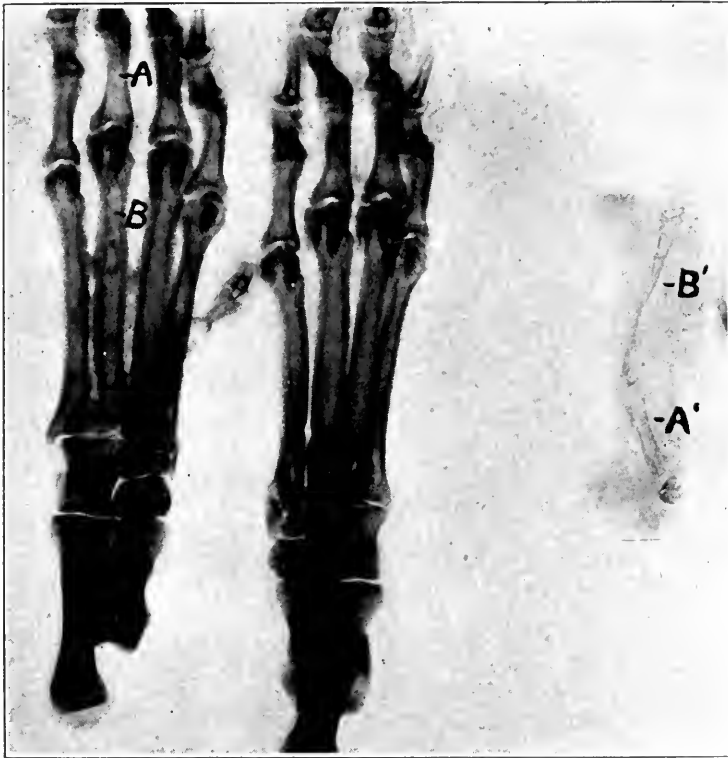


Fig. 4 (Exper. 5, duration 493 days, old animal).—*A*, reimplanted phalanx; *B*, reimplanted metatarsal; *A'*, transplanted phalanx, and *B'*, transplanted metacarpal (relative position is reversed in illustration). There is a very marked difference between the reimplanted and the transplanted bones. The reimplanted bones show very little evidence of absorption in contradistinction to the extensive changes in the transplanted bone as noticed when *A* is compared with *A'* and *B* with *B'*. The ingrowth of bone from the adjoining bones into the reimplanted metatarsal *B* may be noted. The degenerative changes are much less extensive in the reimplanted bones than in the previous experiment (Fig. 3). The degenerative changes are much less extensive and slower in the older animals.

#### FINDINGS, FOUR HUNDRED AND NINETY-THREE DAYS

*Gross*.—(a) The transplant to the back was found encapsulated in the muscles of the back. The bones have undergone marked atrophy and can be easily bent. On section, the cortex is found to be reduced to the thickness of a sheet of paper. The marrow that remains is yellow. The roentgenogram (Fig. 4) shows marked

atrophy and absorption of the bones. It is much more marked than that which has taken place in the reimplanted bones.

*Microscopic.*—(a) The small fragment of the transplant shows that the articular cartilage still possesses stainable nuclei. The osseous tissue shows well stained nuclei in places. One is surprised at the absence of the usual picture seen in bone absorption. This might be due to a cessation of absorption at this time or to a different mode of absorption from that which usually takes place. The nuclei of some of the trabeculae stain; but they are for the greater part stainless and degenerated.

*Gross.*—(b) The reimplanted bones are found healed in their normal position. The joints show some restriction in motion. The metatarsal has fused with the adjoining bones at its base. On section both the metatarsal bone and phalanx are found to have lost the fresh glistening appearance of the marrow and are much drier than normally. The roentgenogram (Fig. 4) shows the absorption of the bones as is evidenced by the irregular outline and rarefaction. The marrow cavity has an irregular outline. The fusion of the metatarsal at its base is well shown.

*Microscopic.*—(b) The articular cartilage stains poorly, especially on the surface. The trabeculae are thicker than normal and in the greater part there is failure of nuclear stain. The marrow elements are absent. The cortex is thinner than normal and its nuclei stain very poorly.

#### COMMENT

In this experiment, the extensive absorption of the inactive transplant to the back is very strikingly shown. The reimplant which is subjected to the normal functional stimulus has undergone a much less extensive and slower absorption. It appears that it too had been permanently damaged and that if new osseous tissue ingrowth did not take place it ultimately would have undergone further absorption.

EXPERIMENT 6 (Duration, three years; reference numbers 139, 83-140, 83, old dog).—(a) The entire third metacarpal of the left fore foot with its corresponding first phalanx and one half of the second phalanx was removed and the entire specimen transplanted to the muscles of the back. The periosteum was stripped from the diaphysis of the metacarpal.

(b) The entire fourth metacarpal of the left fore foot with the entire first phalanx and one half of the second phalanx was removed and the entire specimen reimplanted in its original position.

#### FINDINGS, THREE YEARS

*Gross.*—(a) This animal died during my absence. As there was no specimen obtained from the muscles of the back, it is assumed that it had entirely disappeared. This is very probable in view of the fact that in the previous experiment after the elapse of 493 days, a period less than half that of the present experiment, only a very small remnant of the original transplant remained.

*Gross.*—(b) The reimplanted bones are found healed in the position in which they were placed at the time of the operation. The metacarpophalangeal joint is occupied by fibrous tissue. The phalanx on external examination appears fairly normal, although somewhat smaller than normal. On longitudinal section, the phalanx is found to be more eburnated than normal, and the marrow cavity is occupied by cancellous bone containing some marrow elements. The metacarpal is also smaller than normal, somewhat eburnated and has a small mar-



row cavity. The roentgenogram (Fig. 5) shows the phalanx smaller than normal with an irregular outline. A small marrow space is seen at its distal end. The metacarpal bone is smaller than normal with an irregular outline and marrow cavity.

*Microscopic.*—(b) The phalanx has a smooth articular cartilage at its distal end. A portion of the articular cartilage possesses nuclei which stain, but have an irregular arrangement. In other parts of the cartilage, there is a lack of nuclear staining. The trabeculae of the distal end are thicker than normal with fairly well stained nuclei except at the centers. Very few marrow cells are noticed. The cortical bone of the diaphysis stains fairly well, although in places there is an absence of nuclear staining. The periosteum is rather

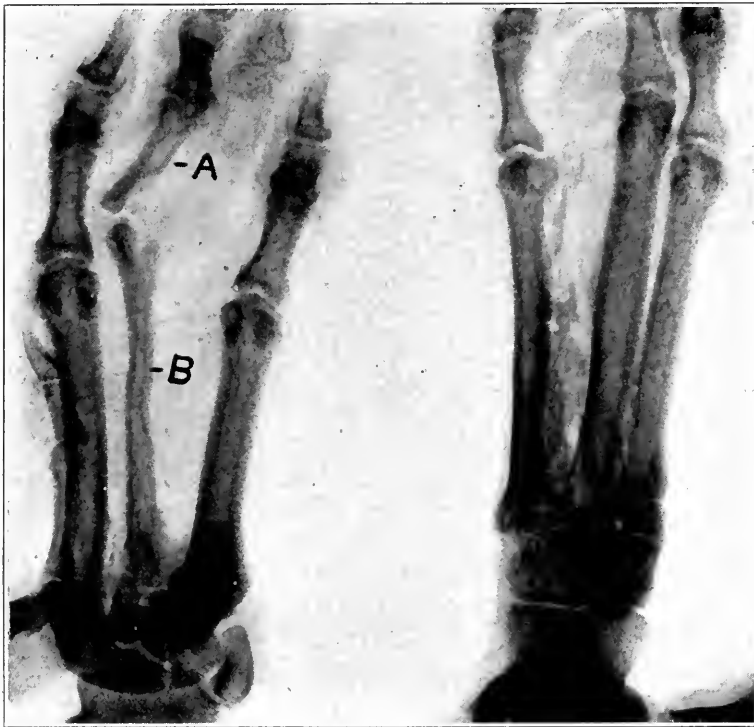


Fig. 5 (Exper. 6, duration three years, old animal).—A, reimplanted phalanx; B, reimplanted metacarpal. The phalanx and metatarsal that were transplanted to the muscles of the back were not recovered, and it is assumed that they were entirely absorbed. The reimplanted phalanx A has undergone moderately extensive degenerative changes. When compared with the adjoining normal phalanges, it is noticed that it is about one-half the width, much less dense, and more irregular in outline. The changes in the metacarpal B are of a similar nature. Thus it is noticed that the reimplanted bones which are subjected to the normal functional stimuli undergo much less extensive and slower degenerative changes than the transplanted bones to the muscles of the back where such stimulation is lacking.

indefinite, and in places there is no differentiation between it and the surrounding fibrous tissue. There is no definite evidence of erosion, but the appearance is that of a slow degenerative process. The proximal articular cartilage has disappeared, being replaced by fibrous tissue. The metacarpal bone shows a complete erosion of the distal articular cartilage with a replacement by fibrous tissue. The trabeculae appear denser than normal, but the

nuclei stain better than those of the phalanx. The nuclei of the cortex stains better than in the case of the phalanx. As with the phalanx, the periosteum is indistinct, blending closely with the surrounding fibrous tissue. Although there is a definite degenerative process going on in the metacarpal, it is of a lesser degree than in the phalanx and the bone appears more viable.

#### COMMENT

The findings in this experiment are similar to those of the previous experiment. The bones transplanted to the back have undergone a complete disappearance while those reimplanted have persisted. Thus it appears that the stimulation of function exerts a decided influence over the fate of bone. It is to be noted that, in spite of the persistence of the reimplant, it shows evidence of a slow absorption, and it would be interesting to know whether the process would continue to the eventual complete disappearance of the bone.

#### GENERAL COMMENT

Before coming to any definite conclusions or deductions from the results of these experiments, it is essential that we carefully analyze the findings in order that due consideration be given to the various factors that may influence and play a contributing part in the complex changes that have taken place in the transplanted bones.

Study of the bones that were transplanted to the muscles of the back reveals a slow progressive degeneration. The extent of the degeneration is proportional to the lapse of time and is practically complete at the end of three years. The osseous tissue in this case is entirely removed from the normal stimulation of function.

The bones that were reimplanted in their normal position underwent a much slower degenerative process, and even after three years at least one half of the bone persisted. The osseous tissue in this case was subjected to the normal functional stimulation.

The question naturally arises as to whether the difference in the behavior of the two sets of grafts can be ascribed entirely to the difference in the functional forces acting on the osseous tissue. There may be other conditions that play a rôle and are responsible at least for some of the differences in the behavior of the two. In the first place, it is noticed that there is a difference in the bed occupied by the two bones, the one in the back being in a muscular bed, while that in the foot occupies a bed consisting of scant fibrous tissue. It is possible that there are more active phagocytic and osteoclastic elements in the muscular tissue, but from the microscopic picture one can see but little difference in the two instances. Another factor to be considered is the difference in the vascularity about the grafts. There is a greater vascularity of the muscular tissue of the back than there is of the fibrous tissue of the foot. An argument may be offered favorable to either side, using vascularity as its basis. It may be asserted that with a richer blood supply there is a greater opportunity for destructive

processes to take place, and it is believed that such an element must be given some consideration. On the other hand, it has been asserted by many that a penetration of blood vessel is of prime importance in determining the viability of a transplanted piece of bone. If such were the case, then it would be natural to expect that the grafts in the back would persist for a longer period on account of the greater blood supply. Granting that these factors may exert some influence over the difference in the behavior of the two sets of grafts, it is quite evident that their importance is small when compared with the undisputed and very evident difference in the functional stimulation to which the osseous tissue is subjected in the two sets of experiments. It, therefore, seems justifiable to ascribe a very important rôle to function in determining the viability of a transplanted piece of bone.

It is noticed that some of the grafts exhibited less evidence of absorption even at a later period than those that were removed earlier. It is possible that the explanation for this apparent discrepancy in the results depends upon the variation in the age of the animals. It has previously been determined<sup>1</sup> that transplants removed from older animals were more resistant to absorption than those from younger animals; and in the particular instances in these experiments in which there was a variation in the degree of degeneration such a difference in age was found to exist. The reasons for the fact that the grafts from older animals show greater resistance to absorption is most likely due to their greater density, to the difference in their chemical constituents, to the thicker and firmer periosteum and to the larger size of the transplant.

It has been maintained that a graft in order to persist permanently must be in contact with the cut surface of live bone in order that there might be an ingrowth of osseous tissue and that certain chemical and physical elements might be supplied by the bone of the host. In these experiments, the phalanx that was reimplanted and was without contact with such denuded bone persisted, even after three years, although one cannot say definitely whether this bone would permanently resist the destructive processes. From microscopic study, there is some evidence that a slow progressive degenerative process is going on in this tissue which still possesses live bone cells. It is possible that after the lapse of a very long period of time there takes place within this osseous tissue, which shows both constructive and destructive processes, a reestablishment of the growth equilibrium and vascularization, under the normal functional stimulation, and that the graft is thereby able permanently to survive. On the other hand, if the destructive forces are superior, the bone will ultimately be absorbed.

From the clinical standpoint, the question arises as to the advisability of using free osseous transplants. Such free transplants have

been utilized in the reconstruction of a lost thumb or other digit. It would be interesting to know the results of these operations after the lapse of a number of years in order to know whether the transplants live permanently. However, should the graft entirely disappear, enough stability would probably be offered by the resultant fibrous tissue to insure sufficient support to the new member to justify this type of operation.

From the practical standpoint the establishment of early function is advisable in order to assist in insuring the success of the operation involving the transplantation of bone. The institution of this early function should not be undertaken if it jeopardizes the osseous union of the graft with the host, a condition which is of prime importance, and, in general, absolutely essential in order to insure the success of the operation.

#### CONCLUSION

1. Function exerts a definite influence over the viability of a transplanted bone.
2. Free bone transplants when subjected to the stimulation of normal function undergo a slower degeneration than similar transplants that are not under such functional influence.
3. Bone transplants from old animals are more resistant to absorptive and degenerative processes than those from young animals.
4. From the practical standpoint the institution of function at the earliest possible moment is advisable in order to aid in insuring the success of the operation involving the transplantation of bone; but this early function should not be established if it jeopardizes the possibility of the bony union between the transplant and the host, a condition that is essential and of prime importance.

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## THE COMPOSITION OF APPENDICEAL CONCRETIONS\*

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Concretions of varying appearance, density and structure are often found in the human appendix, both with and without inflammatory changes in the organ itself. Owen T. Williams<sup>1</sup> has made a particular study of these, calling attention to the fact that the appendix seldom contains fecal material, and that the usual appendiceal stones are not fecal concretions but concentrically laminated concretions, often larger than the lumen of the appendix between the stone and the cecum, and therefore presumably formed by secretion from the wall of the appendix. According to him, the typical appendix concretion is almost white, with a smooth cut surface resembling soap, whereas fecal concretions are pigmented and have a greasy appearance. Like the intestinal sand, they contain fats soluble in ether and soaps insoluble in ether. He analyzed three appendix concretions, and found material soluble in ether to the amount of 14.97, 16.2 and 7.1 per cent., respectively. The fatty acids of soaps insoluble in ether amounted to 15.6, 2.1 and 1.2 per cent., and the amount of calcium was 3.3, 3.6, and 3.2 per cent. He asserts that the calcium exists as soaps, but presents no chemical evidence to establish this opinion.

Bertha Anthony<sup>2</sup> reported the microscopic study of a large number of normal and diseased appendixes, and found material staining pink with scarlet R, sometimes associated with material staining black with silver nitrate, which she also interprets as proving the presence of calcium soaps. As one of us<sup>3</sup> has pointed out, however, silver nitrate does not stain calcium, but indicates the presence of phosphates or chlorids. If a calcium-containing material stains with silver nitrate, it usually means the presence of calcium phosphate, and not the presence of calcium soaps. Therefore, the work of Williams and Anthony furnishes no evidence that calcium soaps are formed in the wall of the appendix, or that such soaps are excreted into the lumen of the appendix to form concretions. Nevertheless, it is highly probable that calcium

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\*From the Otho S. A. Sprague Memorial Institute, and the Department of Pathology, University of Chicago.

1. Williams, Owen T.: *Biochem. J.* **2**:395, 1907; *Brit. M. J.*, July 27, 1907.

2. Anthony, Bertha: *J. M. Res.* **25**:359, 1911.

3. Wells, H. Gideon, *J. M. Res.* **14**:491, 1906.

soaps are present in the appendix, since fats as well as fat-splitting enzymes are present in the bowel, and calcium is excreted largely by way of the intestinal mucosa.

#### ANALYSES IN THE LITERATURE

We have found but two other analyses of appendiceal concretions in the literature.

Roeser<sup>4</sup> examined a concretion weighing 0.56 gm. which had perforated the wall of the appendix and was found free in the peritoneal cavity. It contained 77.2 per cent. of inorganic matter and 11.4 per cent. fatty substance, which were not further examined, quantitatively. Cholesterol, bile pigments and bile acids were missing, the fatty substance was chiefly palmitin, and the inorganic matter consisted almost entirely of magnesium ammonium phosphate, calcium phosphate and calcium carbonate.

Harley<sup>5</sup> analyzed a friable concretion, weighing 1.2 gm., found in an appendix at an operation for appendicitis. Preliminary examination showed organic debris, mostly sclerous vegetable structures, a few granules of silicates, occasional trichocephalus ova, and the absence of bile pigment, cholesterol, bile acids or uric acid. Quantitative analysis of the air dried concretion showed 13.16 per cent. water, 64.61 per cent. ash, and 22.23 per cent. organic matter and material volatilized in ashing. The ash was calculated to contain, in per cent. of the dry matter, magnesium ammonium phosphate, 4.78, calcium phosphate, 63.61, calcium carbonate, 7.54 per cent.; iron and silica, traces. In the organic material was 6.3 per cent. fatty acids. No attempt was made to determine whether any of the fatty acids were combined as calcium soaps. Evidently this concretion was similar in composition to ordinary calcification deposits in necrotic tissues, such as have been described in and about the appendix,<sup>6</sup> and probably represents the calcification of a healed appendiceal abscess, since the stone is said to have been found "au milieu d'adhérences," and is not at all similar to the true appendiceal stones, which Williams found to contain but little calcium.

#### AUTHORS' TESTS

Dr. E. R. LeCount has kindly placed at our disposal for analysis a collection of appendiceal concretions found in appendixes removed at operation, at St. Luke's Hospital, Chicago, and collected during the routine examination of these appendixes in the laboratory. The stones were received preserved in a very little weak alcohol, in three

4. Roeser: J. de pharm. et de chim. **4**:251, 1896.

5. Harley: J. de pharm. et de chim. **2**:433, 1910.

6. Rowan and Wells: Surg., Gynec. & Obst., Oct., 1906, p. 503.

separate lots, of from five to ten stones each; and, to secure information as to the average composition of fecal concretions, the stones in each of the three lots were analyzed together. The masses were generally 5 to 10 mm. in diameter, and for the most part dark brown, only two stones (in Group 2) being made up of concentric layers of a white soapy substance, like the concretions analyzed by Williams. When dried to a constant weight at 100 C., the three collections weighed (1) 4.1413 gm., (2) 3.0049 gm., (3) 5.5842 gm.

The material of each lot after pulverizing was extracted by shaking with 150 c.c. of cold water, and the fatty acids of the water-soluble soaps liberated from these water extracts by acid, were determined.

TABLE 1.—FATTY ACIDS OF WATER-SOLUBLE SOAPS PRESENT IN COLLECTION OF APPENDICEAL CONCRETIONS

Groups	1	2	3
	Per cent.	Per cent.	Per cent.
Fatty acids (gm.).....	0.0090	0.0079	0.0098
Dry weight (per cent.) .....	0.21	0.20	0.17

A small amount of calcium and magnesium were dissolved in water. The percentages of dry weight of these water-soluble constituents are presented in Table 2.

TABLE 2.—WATER-SOLUBLE CALCIUM AND MAGNESIUM PRESENT IN APPENDICEAL CONCRETIONS

Groups	1	2	3
	Per cent.	Per cent.	Per cent.
Calcium .....	0.021	0.07	0.026
Magnesium .....	traces	.....	.....

The residue from the water extraction, after drying, was extracted with absolute ether in a Soxhlet extractor. The extracts thus obtained amounted in per cent. of total dry weight to 20.02 per cent. in Group 1; 17.87 per cent. in Group 2; 15.83 per cent. in Group 3.

The ether extracts were then extracted with hot acetone. The acetone soluble portions contained cholesterol, koprosterol, coloring matter and presumably other lipins in small amounts. The cholesterol was recrystallized from 90 per cent. hot alcohol. It gave the Salkowski and Pettenkofer reactions, and was determined quantitatively by the digitonin method. The koprosterol was crystallized from 85-90 per cent. alcohol and showed the slow development of the orange-red color on addition of chloroform and sulphuric acid which differentiates koprosterol from cholesterol (Abderhalden). The values obtained in percentage of total dry weight are presented in Table 3.

The acetone-insoluble portions were treated with cold ether, which removed the color almost completely and probably some lecithin, since it gave Pettenkofer's reaction (sulphuric acid and sugar). The residue from the cold ether was dissolved entirely in hot amyl alcohol, which dissolves calcium soaps<sup>7</sup> as well as sodium, ammonium and potassium soaps. Soaps were salted out of the water emulsions of these extracts and the melting points of their fatty acids determined. Table 4 shows the amounts of soaps present, calculated in percentages of dry weight, and the percentage amounts of calcium found.

Evidently, then, very little of the soap present in this fraction could have been calcium soaps. The soaps were saponified and the free acids extracted with ether. These fatty acids had the following melting points: Group 1, 49 C.; Group 2, 52 C.; Group 3, 57 C., indicating that they are chiefly mixtures of stearic and palmitic acids with some impurities.

TABLE 3.—CHOLESTEROL, KOPROSTEROL AND LIPINS IN APPENDICEAL CONCRETIONS

Groups	1 Per cent.	2 Per cent.	3 Per cent.
Cholesterol .....	1.6	1.7	0.87
Koprosterol .....	9.6	14.6	9.1
Lipins (by difference) .....	0.19	0.22	0.13

TABLE 4.—SOAPS PRESENT IN APPENDICEAL CONCRETIONS

Groups	1 Per cent.	2 Per cent.	3 Per cent.
Amyl alcohol soluble soaps.....	7.8	0.34	5.3
Calcium .....	0.016	0.03	0.001

The residue from the first ether extraction was extracted with boiling amyl alcohol and the extracts analyzed for calcium and magnesium. The figures presented in Table 5 give the percentages of calcium and magnesium of the total dry weight soluble in amyl alcohol.

The calcium soaps, calculated as calcium stearate from these calcium values, would amount to these percentages of the original dry material: Group 1, 1.1 per cent.; Group 2, 8.9 per cent.; Group 3, 2.56 per cent.

The percentages of original materials extracted with hot amyl alcohol were: Group 1, 38 per cent.; Group 2, 21.9 per cent.; Group 3, 38.8 per cent.

The residue from the first ether extraction was extracted with boiling 1 per cent. nitric acid, and the determinations presented in Table 6 made. Results are given in percentage of original dry concretion.

7. Wells, H. Gideon: J. M. Res. 1906, **14**:359, 1906.



TABLE 5.—CALCIUM AND MAGNESIUM SOLUBLE IN AMYL ALCOHOL

Groups	1	2	3
	Per cent.	Per cent.	Per cent.
Calcium .....	0.22	1.26	0.36
Magnesium ..	0.005	0.006	0.007

TABLE 6.—INORGANIC CONSTITUENTS

Groups	1	2	3
	Per cent.	Per cent.	Per cent.
Carbon dioxid .....	0.84	0.85	0.51
Calcium .....	6.3	13.7	5.01
Magnesium ..	0.83	1.6	1.19
Phosphorus .....	3.6	7.51	3.17
Ammonium .....	0.4	0.35	0.38
Ferric iron .....	0.08	0.2	0.11

These elements may have been combined as shown in Table 7, in per cent. of original materials.

TABLE 7

Groups	1	2	3
	Per cent.	Per cent.	Per cent.
Calcium phosphate .....	13.02	27.17	7.72
Magnesium ammonium phosphate.....	4.73	9.18	6.82
Calcium carbonate .....	1.91	2.05	1.18
Calcium—excess as sulphate or other salts.....	4.6	2.4	2.7

TABLE 8.—RESULTS OF CHEMICAL ANALYSIS OF APPENDIX CONCRETIONS\*

Groups	1	2	3
	Per cent.	Per cent.	Per cent.
Inorganic material .....	24.	41.	18.
Calcium phosphate .....	13.02	27.17	7.72
Calcium carbonate .....	1.91	2.05	1.18
Magnesium ammonium phosphate .....	4.73	9.18	6.82
Calcium (undetermined) .....	4.6	2.4	2.7
Ferric iron .....	0.08	0.2	0.11
Fatty acids liberated from water-soluble soaps.....	0.21	0.20	0.17
Total substances soluble in fat solvents.....	58.23	39.07	54.80
Substances soluble in ether.....	20.02	17.87	15.83
Cholesterol .....	1.6	1.7	0.87
Koprosterol .....	9.6	14.6	9.1
Soaps soluble in both ether and amyl alcohol.....	7.8	0.34	5.3
Other lipins .....	0.19	0.22	0.13
Substances soluble in amyl alcohol and insoluble in ether, probably soaps .....	38.	21.9	38.8
Calcium soaps calculated as calcium stearate.....	1.1	8.9	2.56
Organic residue (not analyzed) .....	17.	20.	26.

\*Figures represent percentages of the original dried material.

The percentage of total calcium found in all forms was: Group 1, 6.55 per cent.; Group 2, 15.06 per cent.; Group 3, 5.37 per cent.

#### SUMMARY

The composition of three collections of concretions found in human appendixes was found to vary somewhat, but in general there was a similarity in the makeup of each lot of concretions (Table 8). They contain about half their weight soluble in fat solvents, this material being chiefly soaps, but with considerable koprosterol and a little cholesterol. Of the soaps but a very small proportion seems to have been calcium soaps. About one fourth of the total weight was composed of inorganic material, chiefly calcium phosphate. About one fifth of the material was organic residue, mostly vegetable fiber, indicating that some part of the appendiceal concretions, at least, comes from the cecum. Probably the rest of the concretions is deposited from the walls of the appendix, since the bowel secretions are known to contain much fatty material and calcium.

We wish to express our indebtedness to Dr. E. R. LeCount for the opportunity to make this study, through his generous gift of the necessary materials.

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## THE PATHOLOGY OF CHRONIC CYSTIC MASTITIS OF THE FEMALE BREAST

WITH SPECIAL CONSIDERATION OF THE BLUE-DOMED CYST \*

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\* Figures 1 to 29 and 32 to 91 from photographs made by Mr. Herman Schapiro; Figures 30 and 31 from paintings by Miss Susie Hayes.

This paper will describe chiefly the pathology of the various types of chronic cystic mastitis as exposed by an exploratory incision. The more detailed clinical and other studies are reserved for a second paper.

#### CLASSIFICATION OF CHRONIC CYSTIC MASTITIS

For the present, I have subdivided this lesion of the breast into the following types, giving my abbreviations and nomenclature for each type:

- BB-12-1,-2,-3: Single or multiple cysts in chronic cystic mastitis, 210 cases.
- BB-13-4,-5,-6,-7,-8: Chronic cystic mastitis without large cysts, 140 cases.
- BB-12-1: The blue-domed cyst, 174 cases.
- BB-12-2: The cyst of the galactoceles type, 8 cases.
- BB-12-3: The multiple blue-domed cysts in one or both breasts (diffuse cystic disease of the breast), 28 cases.
- BB-13-4: The nonencapsulated adenomatous area, 48 cases.
- BB-13-5: The nonencapsulated area of chronic cystic mastitis, containing one or more minute cysts, or one or more dilated ducts, or both, 39 cases.
- BB-13-6: The diffuse dilatation of the ducts, chiefly in the nipple zone, rarely in the breast outside this zone, 22 cases.
- BB-13-7: The nonencapsulated cystic adenoma, 18 cases.
- BB-13-8: The diffuse nonencapsulated cystic adenoma, known in the literature as Schimmelbusch's or Réclus' disease, or senile parenchymatous hypertrophy (Bloodgood), 13 cases.

#### PATHOLOGY IN BRIEF

*BB-12-1. The Blue-Domed Cyst.*—For the gross appearance, see Figures 1 to 8; for the microscopic appearance see Figures 37, 38, 45, 46, 47, 52, 55, 59 and 73.

The characteristic gross feature is a distinct blue dome (Figs. 1 and 2). This can be recognized if, when cutting down over the tumor, one proceeds slowly, checks hemorrhage, and from time to time moves the knife from side to side. The blue dome in the majority of cases is exposed after dividing the subcutaneous fat. In a certain percentage of cases, the cyst is buried in breast tissue, and one must divide a zone of breast before exposing the cyst. Very rarely is the cyst situated behind the breast on the pectoral fascia (Fig. 4).

When the cyst wall is nicked, its color immediately disappears. The cyst wall is, as a rule, thin (1 mm.); in less than 10 per cent. of the cases it has been thicker (2 to 3 mm.). The contents of the cyst have never been hemorrhagic—they are either clear or cloudy; in four cases (all from outside surgeons) they have been noted as "brown." In all of my own cases, they have been clear or cloudy. The inner wall of the cyst is smooth, without papilloma, and there may be partial partitions or septums.

*B B-12-2. The Cyst of the Galactocoeles Type.*—For the gross appearance, see Figures 9 and 10; for the microscopic appearance, see Figure 44.



Fig. 1 (Path. No. 25508. BB-12-1 [T]).—Blue-domed cyst, unopened, projecting from the surrounding breast; excised zone of breast, adenomatous. Result (1921): Well, six months after incision of cyst with zone of breast. See page 469.

In this and the following legends the abbreviations for operative procedures are: [T] excision of tumor and zone of breast only; [B] excision of one breast without exploratory incision; [BB] excision of both breasts without exploratory incision; [CC] complete operation for cancer without exploratory incision, and [Expl.] exploratory incision.



Fig. 2 (Path. No. 27762. BB-12-1 [T]).—Blue-domed cyst, unopened, projecting from zone of breast. See Figure 3 for cross-section; also see page 470.

This type is less frequent than the blue-domed cyst—as 8 cases are to 174, and differs from the blue-domed cyst in that, when its dome is exposed, it is white or gray. As a rule, the wall is a little thicker. The contents not only resemble milk in appearance, but also are coagulated by liquor formaldehydi, while the contents of the blue-domed cyst are not.

*BB-12-3. Multiple Cysts in One or Both Breasts (Diffuse Cystic Disease of the Breast).*—For the gross appearance, see Figures 11 and 12; for the microscopic appearance, see Figures 36, 43, 48 and 62.

The cysts are of the blue-domed type; a few may be of the galactoceles type. The breast, or breasts, are riddled with cysts of various sizes. The character of the wall and the contents are identical with those of the blue-domed cyst or the cyst of the galactoceles type. The frequency of this multiple cystic disease of the breast is as 28 to 210, or about 13 per cent.

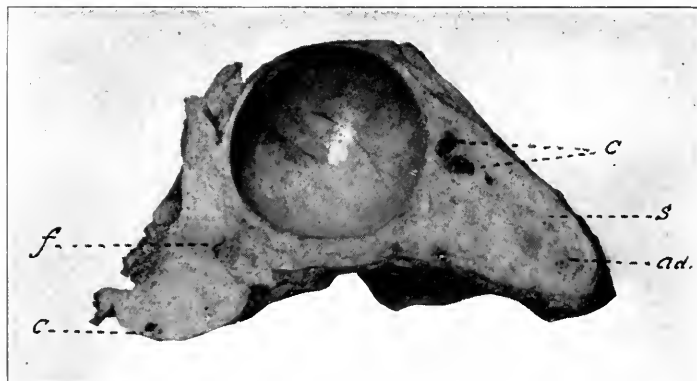


Fig. 3 (Path. No. 27762. BB-12-1 [T]).—Section through blue-domed cyst and zone of breast excised, shown in Figure 2: *C*, minute blue-domed cyst; *Ad.*, adenomatous area; *S*, fibrous stroma; *F*, fat. Result (1921): Well, four months after excision of cyst with zone of breast. See page 471.

*BB-13-4. The Nonencapsulated Adenomatous Area.*—For the gross appearance, see Figures 13 and 14; for the microscopic appearance, see Figures 35 and 69.

When this type occurs clinically as a single definite tumor, one must explore to exclude a malignant lesion. Then the palpable tumor will appear as a nonencapsulated area of breast tissue, in which the elevated pink and gray dots representing the adenomatous lobules are more numerous than in the surrounding breast. This area resembles somewhat the fibro-adenoma, but has less stroma. When this type presents itself clinically, as multiple, somewhat indefinite, nodules in one or both breasts, each nodule is practically identical in the gross

and microscopic picture. I am inclined to the conclusion that, when multiple, the disease corresponds to that described by Warren, of Boston, as the *cobble-stone breast*, and my recent experience teaches me that operation is *not* indicated when one can make out multiple, indefinite nodules in both breasts. However, when there is a single definite tumor, it must be explored.

*BB-13-5. Nonencapsulated Area of Chronic Cystic Mastitis Containing One or More Minute Cysts, or One or More Dilated Ducts, or Both.*—For the gross appearance, see Figure 15; for the microscopic appearance, see Figures 32, 63, 67 and 68.



Fig. 4 (Path. No. 25560. BB-12-1 [CC]).—Blue-domed cyst surrounded by fatty senile breast. Result (1921): Well, eighteen months after complete operation for cancer. See page 471.

When this type appears clinically as a single tumor, it must be explored. It differs in the gross from the nonencapsulated adenomatous area (BB-13-4, Figs. 13 and 14) only in the presence of one or more minute cysts, or one or more dilated ducts. If the latter are present, there is liable to be mastitis (Figs. 15, 63 and 67).

This type may also occur clinically as multiple indefinite nodules, and corresponds to Warren's cobble-stone breast. Operation is not indicated, unless there is a single definite tumor which must be explored.

It is important to note here that among 140 cases of chronic cystic mastitis of the types BB-13 (-4,-5,-6,-7 and -8) eighty-seven, more than 50 per cent., belong to the groups BB-13 (-4-5) and in many of these cases the clinical picture was that of the cobble-stone breast of Warren, in which operation is not indicated. In this group BB-13 (-4-5) in which there are eighty-seven cases, many breasts were unnecessarily sacrificed because of the fear of cancer, inability to make a correct clinical diagnosis, or to interpret the gross and microscopic picture at the exploratory incision.

*BB-13-6. Diffuse Dilatation of the Ducts Chiefly in the Nipple Zone, Rarely in the Breast Outside This Zone.*—For the gross appearance, see Figures 16 to 20; for the microscopic appearance, see Figures 49, 50, 51, 65, 66 and 78.



Fig. 5 (Path. No. 10940. BB-12-1 [T]).—Section through blue-domed cyst and zone of excised surrounding breast. Note thin, smooth wall of large cyst; surrounding breast adenomatous; a few dilated ducts (DD) which contained creamlike material; also much stroma and fat. Result (1921): Well, eleven years after excision of cyst with zone of breast. See page 473.

The characteristic clinical picture when the dilated ducts are situated in the nipple zone is the palpation of a doughy, wormlike mass beneath the nipple. When explored, one can recognize large and small dilated ducts with distinct walls containing brown, green, milky or creamlike material, of various degrees of viscosity and consistency. The contents when expressed appeared as soft, wormlike masses, exposing the distinct, smooth wall of the duct—a gross picture, if carefully inspected, different from that of the comedo-adenoma.

When it occurs in a zone of breast outside the nipple area (Fig. 19), it feels like diffuse mastitis, but has not the distinct edge or border of BB-13 (-8) the diffuse nonencapsulated cystic adenoma.



My recent experience indicates that when one can diagnose this lesion by palpating the wormlike tumor beneath one or both nipples, operation is not indicated.

*BB-13-7. Nonencapsulated Cystic Adenoma.*—For the gross appearance, see Figures 21 and 22; for the microscopic appearance, see Figures 53, 58, 60, 64, 70, 71, 72, 74, 75, 77, 79, 80, 81, 82, 86, 87, 90 and 91.



Fig. 6 (Path. No. 27007. BB-12-1 [T]).—Section through a large blue-domed cyst and surrounding breast, showing the small dark areas in the wall of the large cyst. These are due to minute areas of hemorrhage (Fig. 46). The surrounding breast shows one minute cyst, one dilated duct without contents, and a few adenomatous areas. The breast consists chiefly of fibrous stroma and fat. Result (1921): Well, eight months after excision of cyst with zone of breast. See page 476.

This tumor, in the gross, does not differ from BB-16, the *encapsulated* cystic adenoma. We have twenty-two examples of the encapsulated cystic adenoma, and eighteen of the *nonencapsulated*.

After most careful restudy of all the gross and microscopic specimens, I can see practically no difference between the two lesions, except the absence of a capsule in the *nonencapsulated* cystic adenoma, the presence of a little more fibrous tissue, and (one example) the presence of scirrhou carcinoma, in combination with the nonencapsulated cystic adenoma (Figs. 86 and 87).

In the twenty-two cases of encapsulated cystic adenoma, the surgeons removed the tumor only. When sections are submitted to many pathologists, the diagnosis of *adenocarcinoma* is frequently made. But there has been no recurrence in any of these twenty-two cases, notwithstanding the fact that only the tumor had been removed.



Fig. 7 (Path. No. 21770. BB-12-1 [T]).—Blue-domed cyst, unopened, and zone of surrounding breast. See Figure 8 and page 479.

In contrast, all the eighteen cases of BB-13-7, the nonencapsulated cystic adenoma, except one, have ultimately been subjected to the complete operation for cancer. None showed metastasis to the axillary glands; in none has there been recurrence or death from cancer.

*BB-13-8. Diffuse, Nonencapsulated Cystic Adenoma (Known in the Literature as Schimmelbusch's or Réclus' Disease).*—For the gross appearance, see Figures 23 to 29; for the clinical picture when associ-

ated with retracted nipples, see Figure 29; for the microscopic appearance, see Figures 39, 40, 41, 42, 54, 56, 57, 61, 76, 83, 84, 85, 88 and 89.

The characteristic clinical picture in these thirteen cases is the palpation of a zone of mastitis in which one can feel many small, shotlike masses. The edge of the involved breast is distinctly palpable. The disease may involve a quadrant, a hemisphere or both breasts. In a few cases, it is associated with intermittent retraction of the nipple; and if operation is delayed, the retraction becomes permanent (Fig. 29).

The clinical picture is so distinct and characteristic that one need not explore. The gross appearance and the microscopic picture are identical with the encapsulated and the nonencapsulated cystic adenoma (BB-13-7).



Fig. 8 (Path. No. 21770. BB-12-1 [T]).—Section through blue-domed cyst shown unopened in Figure 7, and second, small, cyst. In the surrounding breast there are a few minute cysts and a few dilated ducts; contents of the latter, grayish-brown, pastil material; also marked increase of adenomatous areas; very little fat. For microscopic area, see Figures 47 and 55. Result (1921): Well, five years after excision of cyst with zone of breast. See page 479.

In one of the thirteen cases there was a gross and microscopic area of cancer (Figs. 88 and 89). In this instance the clinical and gross picture was malignant (Fig. 28), and the patient died of metastasis after the complete operation for cancer. The incidence of malignancy is therefore less than 10 per cent.

PATHOLOGY OF THE BREAST SURROUNDING THE VARIOUS TYPES  
OF CHRONIC CYSTIC MASTITIS

(BB-12-1,-2,-3 and BB-13-4,-5,-6,-7 and -8)

There is nothing in the gross or microscopic pathology of the breast surrounding these different types of palpable tumors which would allow one to distinguish the types of the tumor which lead to operation. These breasts, as a rule, show some evidence of chronic cystic mastitis in the presence of increased adenomatous areas, minute cysts and dilated ducts. The remaining breast tissue now and then is *senile*. The blue-domed cyst, BB-12-1, and the diffuse dilatation of the ducts beneath the nipple, BB-13-6, have been observed in the *senile* breast more frequently than any other type.

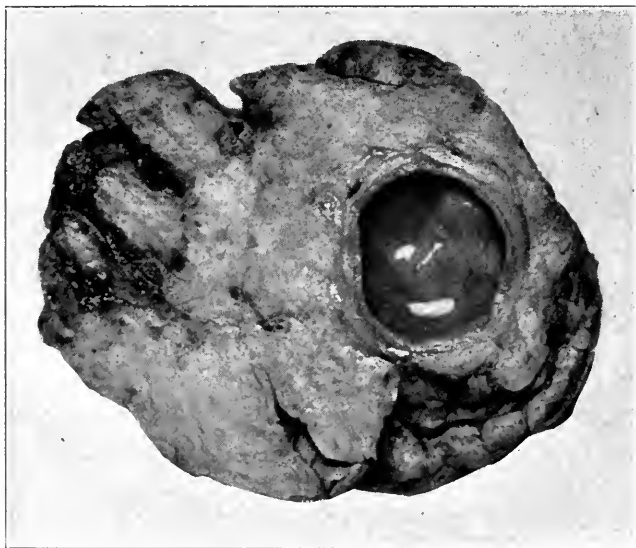


Fig. 9 (Path. No. 26803. BB-12-2 [T]).—Section through white-domed cyst of the galactocoele type. The milklike contents of the cyst have coagulated. The surrounding breast is chiefly fibrous stroma mixed with fat, a few adenomatous areas and a few dilated ducts without contents. Specimen sent by Dr. Butt of Davis, W. Va. Result (1921): Well, nine months after excision of cyst and zone of breast. See page 482.

When one cuts out the blue-domed cyst or the cyst of the galactocoele type, or one or more of the multiple blue-domed cysts, or the nonencapsulated adenoma, or the nonencapsulated adenoma with cysts or dilated ducts, or the diffuse dilatation of the ducts, or the nonencapsulated cystic adenoma, or the diffuse nonencapsulated cystic adenoma, one may see almost normal breast on the one hand, or *senile* breast on the other; or the breast may simply show increased adenoma-

tous areas similar to BB-13-4, or minute cysts and dilated ducts, similar to BB-13-5. If the lesion is situated near the nipple, one may expose diffuse dilatation of the ducts almost as pronounced as in BB-13-6.

The relative proportion of the various changes in the breast has no practical significance, nor is it of itself an indication for the removal of the breast. In every type, a zone has been removed, and among these cases, every possible type of chronic cystic mastitis, *except* BB-13-8, has been cut through in removing the palpable tumor, and the results have demonstrated no difference.

This is a very important observation, because many surgeons, when not influenced to remove the breast by the exposed palpable tumor, have been influenced to remove the breast because of the appearance of the surrounding breast tissue. My conclusions are that chronic cystic mastitis is not a lesion of the breast which at the present may



Fig. 10 (Path. No. 25517. BB-12-2 [T]).—Section through white-domed cyst buried in breast tissue. The contents of the cyst consisting of milk-like material, were removed at operation. The surrounding breast shows mastitis (irregular, opaque-white areas), a minute cyst, adenomatous areas, no fat. For microscopic picture, see Figure 44. Result (1921): Well, three years after excision of the cyst and zone of breast. See page 484.

be considered *precancerous*, and its presence does not demand either the complete excision of the breast, or the complete operation for cancer.

For the present, in BB-13-7 and -8 the isolated and diffuse non-encapsulated cystic adenoma, it may be safer completely to remove the breast, or to perform the complete operation for cancer because of the incidence of cancer in two out of 31 cases, less than 10 per cent.

*Cancer in the Surrounding Breast.*—One of my colleagues, in discussing my paper in New Orleans before the Section on Surgery of the American Medical Association, expressed the opinion that one must have the entire breast in order to exclude cancer. If this were true,

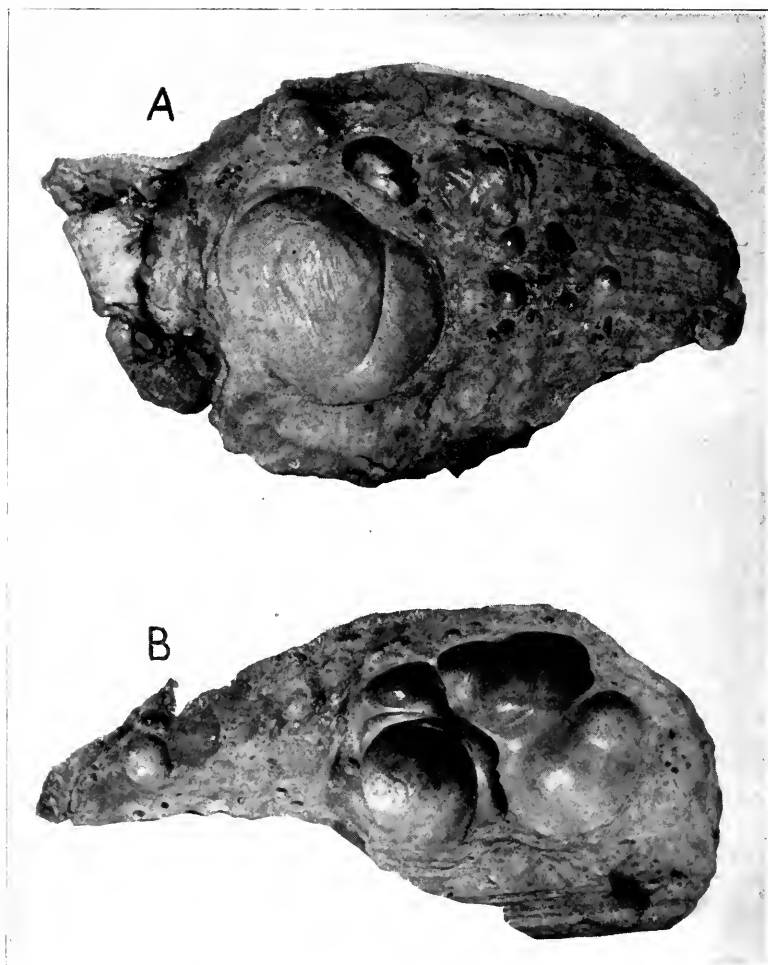


Fig. 11 (Path. No. 26139. BB-12-3 [BB]).—Section through entire breast showing multiple large and small blue-domed cysts—the typical cystic disease of the breast. Specimen sent by Dr. Royster of Raleigh, N. C. Result (1921): Well, eleven months after removal of both breasts. See page 487.

there could be no conservative treatment of benign breast lesions, and there would be no stimulation for differential diagnosis.

The results of my investigation are as follows: Among the 350 cases of chronic cystic mastitis of the various types here described,

we have had an opportunity to study the entire breast in 222 cases in which it was removed. In not a single instance have we found *gross* or *microscopic cancer*. The same is true of about 600 benign breast

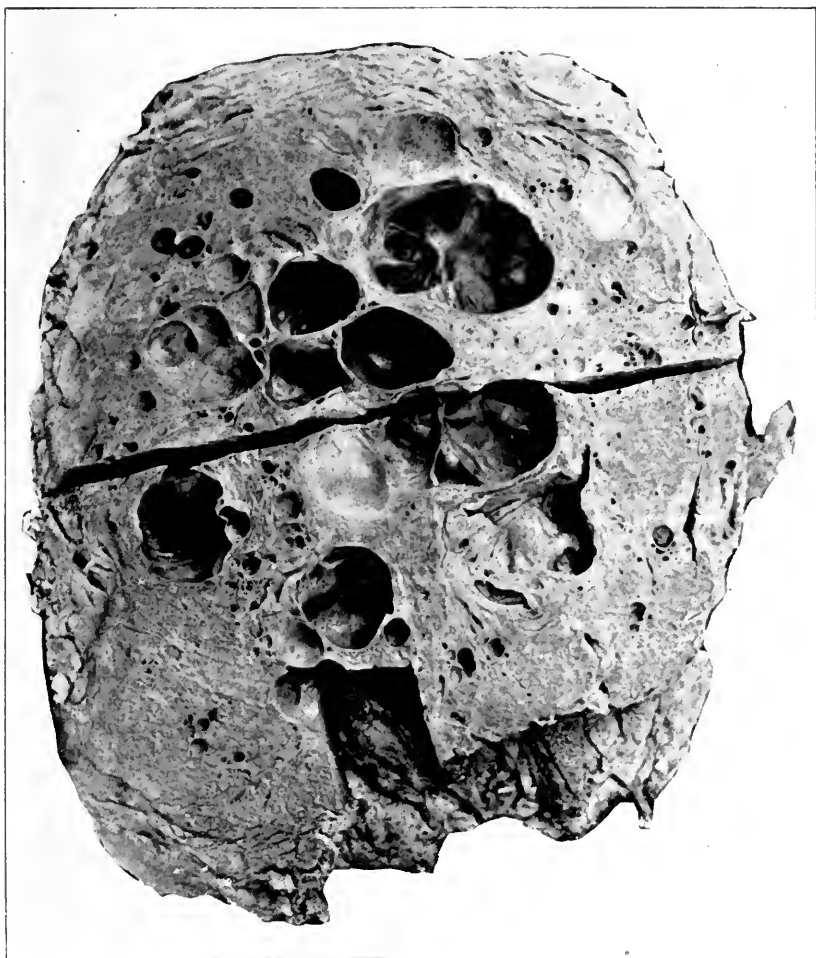


Fig. 12 (Path. No. 4903. BB-12-3 [B]).—Section through Breast, showing multiple small and large cysts of the blue-domed type, a few empty dilated ducts and a few dilated ducts with granular contents. This is the typical cystic disease of the breast. The breast was excised in Johns Hopkins Hospital in 1903. Result (1921): Well, eighteen years after removal of the breast. The multiple tumors in the remaining breast have disappeared. See page 488.

lesions other than those discussed here. Many of these breasts were unnecessarily removed, thus allowing complete study of the breast tissue.

Among the 350 cases recorded here as chronic cystic mastitis, I mentioned two—the *only two*—in which the microscope revealed positive cancer. One of these was an example of BB-13-8, diffuse non-encapsulated cystic adenoma (Figs. 28 and 88) and was clinically malignant, and the area of cancer was picked out *in the gross*. In the other case, BB-13-7, the area of cancer was recognized in the non-encapsulated cystic adenoma at the exploratory incision.

Therefore, as far as my experience goes with more than 900 benign breast lesions, I have no evidence that one needs more than the palpable tumor, exposed at operation, to make the differential diagnosis.

Of course, if one starts to excise what appears to be a benign tumor and finds in cutting through the surrounding breast tissue an area of cancer, one would immediately proceed with the complete operation for cancer. Up to the present, I have never had such an experience.

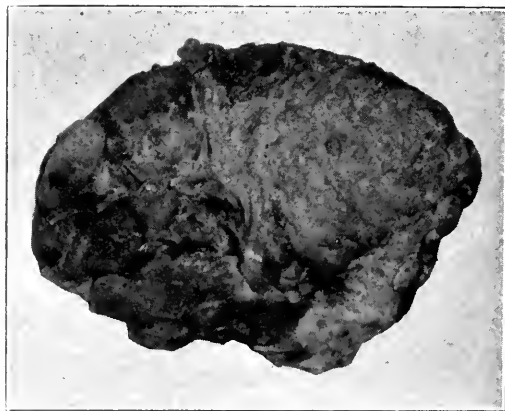


Fig. 13 (Path. No. 26695. BB-13-4 [T]).—Section through a zone of breast containing a nonencapsulated area of the fibro-adenomatous type. The nonencapsulated tumor is to the right; the fibrous and fatty breast to the left; there are no cysts or dilated ducts. For microscopic picture, see Figures 35 and 38. Result (1921): Well, nine months after excision of zone of breast shown in illustration. See page 491.

Among about 1,200 cases of *cancer* of the breast, we have either recognized the case clinically as malignant and performed the complete operation without exploratory operation, or, when it has been necessary to explore and we have recognized the malignancy of the tumor, the surrounding breast has not been helpful in the differential diagnosis.

*Incidence of Cancer in Chronic Cystic Mastitis.*—First, we must consider how frequently cancer has developed when we have removed only the tumor and left the breast. This has happened on only three occasions among 128 cases.



The development of cancer in the breast after the removal of a zone of breast, the seat of chronic cystic mastitis, is apparently not more frequent than the normal incidence of cancer in the same number of women at the same age, who had not been operated on: three out of 128 cases—about 2 per cent.

Two of these patients died of cancer, both of whom were operated on by outside surgeons; one, my own patient, is living seven years after the operation for cancer.

*Conservative Operations for the Different Types of Chronic Cystic Mastitis.*—Of 350 cases the tumor only has been excised in 128, or about 37 per cent. I am confident that this is too small a number, and in a second paper I will discuss this in detail.

*Clinical Diagnosis.*—The essential feature is the palpation of one or more distinct lumps. The diagnosis rests more on this than on any other data to be obtained from the history or examination.

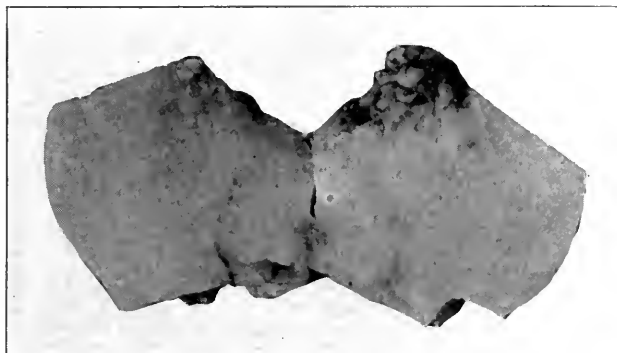


Fig. 14 (Path. No. 14923. BB-13-4 [T]).—Section through zone of breast excised, showing a nonencapsulated area of the puberty-adenomatous hypertrophy type. For microscopic picture, see Figure 32. Result (1921): Well, eight years after excision of zone of breast shown in illustration. See page 494.

*Age.*—If the patient is 25 years of age or under, this, for practical purposes, almost excludes cancer.

*Duration of Tumor.*—If the tumor has been present for two or more years and has not grown, and there is no change in the nipple or skin, the chances are that it is benign. But there are sufficient exceptions to this rule in patients over 25 years of age not to justify delay. The lump should be explored: if benign, it should be removed; if malignant, it must be followed at once by the complete operation for cancer.

*Multiple Tumors.*—One distinct tumor in each breast, or more than one tumor in one or both breasts, still clinically benign, practically makes the diagnosis of a benign lesion. All the types of chronic cystic

mastitis may present the clinical picture of multiple, distinct tumors in one or both breasts. This occurs most frequently with distinct cysts, and less frequently in the other types. Benign encapsulated adenoma of the three types—fibro-adenoma, intracanalicular and cystic adenoma, and lipoma occur as multiple tumors in one or both breasts.

On only two occasions have I observed cancer to begin simultaneously in both breasts. In these two instances, the clinical picture was malignant, because the patient had delayed seeking advice. In a very few cases of malignant tumor, there have been two or more palpable masses in the breast. However, in every case one or more of the distinct tumors have been clinically malignant, that is, associated with changes in the skin or retraction of the nipple. Therefore, the

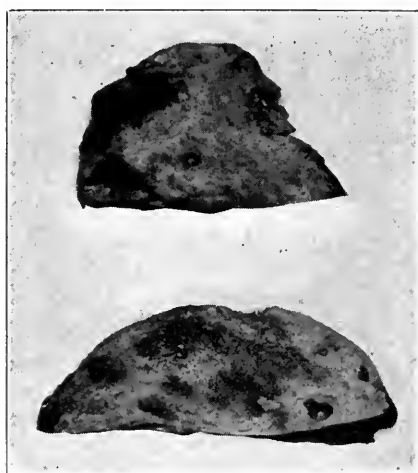


Fig. 15 (Path. No. 26771. BB-13-5 [T]).—Section through nonencapsulated area of breast containing two slightly dilated ducts with yellow, cheesy, granular contents, two minute cysts, adenomatous areas and mastitis. For microscopic pictures, see Figures 63, 67 and 68. Result (1921): Well, ten months after excision of affected zone of breast. See page 499.

palpation of two or more tumors in one or both breasts, still clinically benign, may be looked on as evidence that they are pathologically benign. However, it might be safer, unless one has had a large experience, to explore and remove one of the tumors.

To make the mistake of diagnosing multiple tumors benign when they are really pathologically malignant, would, from my evidence, not be losing an opportunity to save a life. We have never cured a case of cancer in which the tumors were multiple and malignant.

*Single Definite Tumor Associated With Multiple Indefinite Nodules, or Multiple Shotlike Nodules in One or Both Breasts.*—This finding,

which, in my experience, is a definite clinical picture, rests on the most careful palpation of both breasts, a refined sense of touch and experience. This clinical picture does not exclude the possibility that the single tumor may be malignant. It indicates that the larger probabilities are that the entire pathologic process is benign and due to chronic cystic mastitis. The single definite tumor, unless clinically malignant, should be explored. If clinically malignant, the complete operation for cancer should be performed.

*No Definite Tumor in Either Breast, but Multiple Indefinite Nodules, or Small, Shotlike Nodules in Both Breasts.*—Among our 350 cases of chronic cystic mastitis, all in the groups BB-13-4 and -5, a number of patients have presented this clinical picture, and one or both breasts have been unnecessarily removed. I now have records

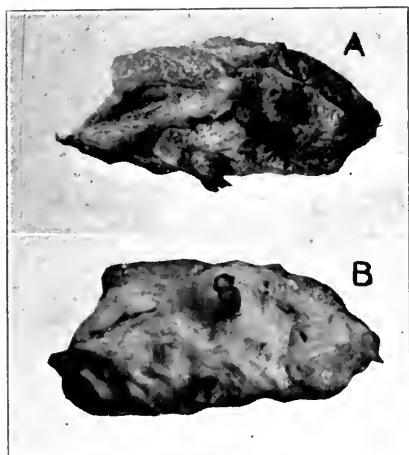


Fig. 16 (Path. No. 19767. BB-13-6 [B]).—Dilatation of ducts beneath the nipple. The section of the breast beneath the nipple shows a small dilated duct with thick wall surrounded by fibrous breast stroma and, in each illustration, a wormlike, brown mass of viscid granular material projecting from the breast tissue. This material represents the wormlike contents of the ducts. Result (1921): Well, five years after excision of the breast. See page 503.

of forty-four cases with the identical clinical picture in which I have advised against operation; and these patients, followed for fifteen or less years, have not developed cancer. This is a larger number than those subjected to operation in groups BB-13 (-4 and -5).

*Important Facts in Previous History.*—If we can obtain a definite history of a disappearing tumor, or of variation in size of the present palpable tumor, this favors the diagnosis of chronic cystic mastitis. Such a history has been obtained in less than 1 per cent. of malignant tumors, and in more than 15 per cent. of well taken histories of chronic mastitis.

The history of the previous excision of one or more benign tumors from either breast is evidence in favor of the assumption that the present tumor is benign, especially if the excised tumor was a blue-domed cyst. Also, when there is a history of excision of one breast for a benign lesion, this favors the diagnosis of benignity in the remaining breast. On the other hand, the history of operation for cancer in one breast favors the diagnosis that the palpable lump in the other breast is malignant.

*Single Tumor in One Breast, the Remaining Portion of This and the Other Breast Normal.*—On the whole, this is the most frequent clinical picture. If there is a definite tumor, and the patient is 25 years of age, or over, immediate operation is indicated.

*Single Tumor, Clinically Malignant.*—In a few cases the trained sense of palpation may enable one to recognize malignancy by touch alone. However, in the majority of cases, the diagnosis rests on retraction or fixation of the nipple, atrophy of the subcutaneous fat, dimpling of the skin, adherent or red skin.

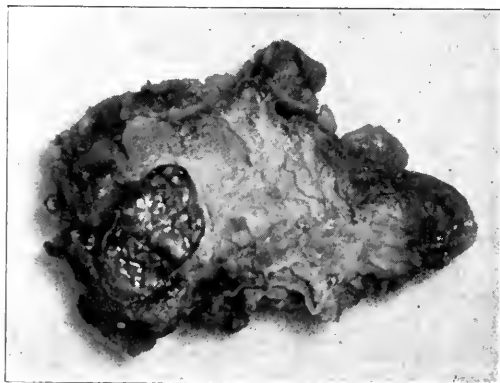


Fig. 17 (Path. No. 24650. BB-13-6 [T]).—Dilatation of ducts beneath nipple. Section through zone of breast excised. Note the slightly dilated, tortuous, unopened duct; the large, collapsed, empty duct, and the dilated duct filled with brown, grumous material. Result (1921): Well, two years after operation. Similar condition in other breast has disappeared. See page 504.

It is true that a certain percentage of benign tumors of all types may give the sensation of malignancy to the palpating finger, or be associated with changes in the nipple or skin, which are usually associated with malignancy. Should the operator perform the complete operation for cancer in all of these benign lesions which present the clinical picture of malignancy, the number of women mutilated would be relatively small.

A large experience will be helpful in the recognition of this benign group and save the patient mutilation. When the palpable tumor is

in the nipple or in the areolar zone, changes in the nipple and skin are less significant of malignancy, than when it is situated outside the nipple zone. This important part of the diagnostic problem will be discussed in detail in a second paper.

*Single Tumor Clinically Benign.*—Now that women are being educated to seek advice the moment they feel a lump in the breast, this clinical picture is becoming more and more frequent; and at the present time, we have no method of diagnosis, except the palpation of the lump and its exploration. The number of benign tumors in women, more than 25 years of age, in whom it is necessary to remove only

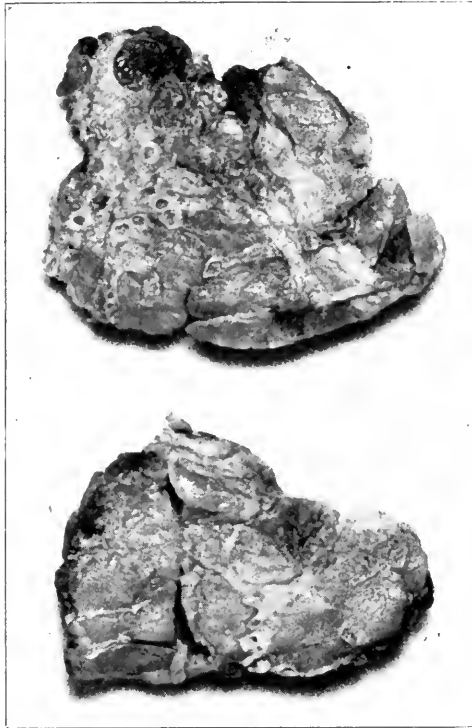


Fig. 18 (Path. No. 27114. BB-13-6 [T]).—Dilatation of ducts beneath the nipple. Section through excised zone of breast beneath nipple shows empty and filled dilated ducts, with a definite ring (the thick wall) surrounded by fibrous breast stroma and fat. In the upper left margin of the upper picture are two large dilated ducts with brown, granular, viscid contents. Result (1921): Well, seven months after excision of zone of breast. See page 507.

the tumor, is too large to justify the removal of the breast, or to perform the complete operation for cancer without first ascertaining the pathology of the palpable lump by exploratory incision. I have records of at least 750 benign lesions of the breast in women, over 25,

of which 350 or almost 50 per cent. belong to the type of chronic cystic mastitis.

In the majority of these cases, both breasts can be saved; and these women run no more risk of cancer than any other group of women of the same age.

*Palpation of the Breast.*—The educational propaganda is influencing many women to seek immediate advice because of pain or the palpation



Fig. 19 (Path. No. 21192. BB-13-6 [B]).—Dilatation of ducts in zone of breast outside the nipple area. Section of breast shows chiefly the thick, cream-like material covering the cut surface of the breast, which has been expressed. This obliterates the picture of the dilated ducts. Toward the right edge of the breast one dilated duct and near it a small worm projecting from the duct may be noted. For microscopic appearance, see Figure 78. Result (1921): Well, four years after excision of the breast. See page 511.

of a lump in the breast. I have records of many patients who thought that they had felt a lump, or whose physician had thought he had felt a lump, and who on examination by me were found to have either no lump (sixty-one cases), or a lump which was one of many indefinite

lumps (forty-four cases), or one which was due to simple enlargement of the axillary portion of the breast (twenty-four cases). Here, therefore, we have 129 women who sought advice early because of the educational propaganda, whose breasts on careful palpation presented no indication for operation.

It is therefore of the greatest importance for all members of the profession who assume the responsibility of diagnosing breast lesions to improve their sense of palpation.

*Exploratory Incision.*—It is my rule always to examine the patient on the day of operation before the area is cleaned, to check up the previous examination and to consider again whether the lump should be explored.

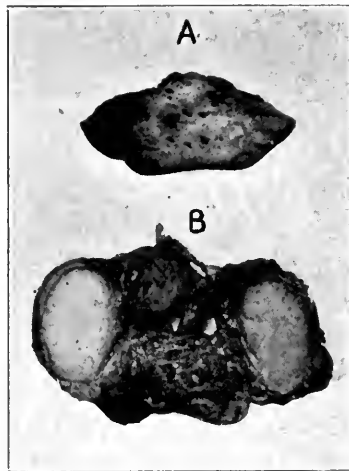


Fig. 20 (Path. No. 27935. BB-13-6 [CC]).—Dilatation of ducts beneath nipple, with abscess formation in one duct: *a*, a section through the breast beneath the nipple, containing dilated ducts with thick wall. In the left margin, there is a small cavity lined by granulation tissue—an abscess due to infection of a dilated duct; *b*, a cross section through an axillary gland; this under the microscope showed no metastasis. Specimen sent by Dr. Loos of Bay City, Texas, who recognized the condition as benign from the gross appearance (recent case). See page 510.

The patient is always prepared for the complete operation for cancer and for general anesthesia. The exploration can be made under procain or gas. One should have on the operating table a medicine glass of pure phenol, one of 95 per cent. alcohol, and a third of 50 per cent. solution of zinc chlorid, with swabs.

The incision should be made directly over the lump. The moment the operator exposes the tumor and concludes that it is malignant, the exposed area should be swabbed with pure phenol followed by alcohol,

the wound packed with a piece of gauze saturated with the zinc chlorid solution, and closed. Then one should proceed at once with the complete operation for cancer.

In a few cases, the palpable lesion is so small, and the breast so large and fatty, that I have excised a zone in which the palpable lump was situated, packed the wound with an alcohol sponge, and then explored the tumor. Up to the present it has proved to be malignant in only one instance. In this case, I burned the wound with the cautery, packed it with zinc chlorid gauze, closed it, and proceeded with the cancer operation. This patient is well (1921), five years since operation.

When the operator feels that he must have a frozen section, what shall be the method? Cut out a piece of the tumor and wait, or cut out a zone of breast about the tumor and wait? I should favor the latter course, that is, to excise the tumor with a good zone of breast and temporarily pack the wound with an alcohol sponge.



Fig. 21 (Path. No. 17012. BB-13-7 [Expl. CC]).—Nonencapsulated cystic adenoma (natural size) and piece of surrounding breast tissue. This tumor has the appearance of cancer. The fine dots and lines on the cut surface may be noted. It felt and cut like cancer. For microscopic appearance, see Figures 90 and 91, which show a benign papillary cystadenoma. Operation (Bloodgood): Exploratory incision followed immediately by the complete operation for cancer. Result (1921): Well, six and one-half years later. See page 515.

Up to the present time, in my own operations, my decision as to the removal of the tumor or the complete operation for cancer has rested on the gross inspection and palpation of the explored lesion, and I have not waited for the frozen section. Each operator must choose his own method, which should be influenced by the results.

*What to Do in Case of Doubt.*—When one explores a palpable area of the breast and, after gross inspection, with or without the aid of an immediate frozen section, one is still doubtful as to malignancy, I believe the safer rule is to cauterize the area as described and perform the complete operation for cancer. The object of this and subsequent papers is to describe and illustrate the gross and microscopic pathology of the different lesions of the breast, so that we may reduce the number of unnecessary complete operations for benign lesions.



*The Mistake That Should Not Be Made.*—I am confident from the experience of Dr. Halsted's clinic in Johns Hopkins Hospital since 1899 and from my own cases, and from the tissues and records sent to me by other surgeons, that the mistake of performing an incomplete operation for malignant disease is unnecessary. Cancer of the breast is a distinct gross picture—just as distinct as that in the frozen section—and in this group any surgeon whose experience justifies him in assuming the responsibility for the operation should, and, as far as my records go, does recognize distinct cancer and performs the complete operation.

*The Mistake That Is Made and Which Produces No Harm but Mutilation.*—This is the complete operation for benign lesions of the breast, especially for chronic cystic mastitis.



Fig. 22 (Path. No. 1210. BB-13-7 [CC]).—Section through nonencapsulated cystic adenoma and surrounding senile breast. Gross description by Bloodgood, in 1896: "Tumors size of twenty-five-cent piece, circumscribed, in places infiltrating; large cellular alveoli divided by fibrous trabeculae. Tumor looked and felt like cancer, but a solid intracystic papilloma is considered possible." For microscopic appearance, see Figure 77, showing benign papillary cystadenoma. Because of the retracted nipple, Dr. Halsted performed the complete operation for cancer. Result: Death from apoplexy at the age of 75, thirteen and one-half years after operation. The glands in the axilla showed no metastasis. See page 513.

This is due to the fact that the relation of chronic cystic mastitis to cancer has been exaggerated in the literature. It is also due to the fact that pathologists disagree as to the histologic picture of the zone of breast about the cyst and of the group BB-13-4 to -8. Some of these nonencapsulated lesions closely resemble cancer (Fig. 21).

Until, therefore, we have established a method of differential diagnosis, the mistake of occasionally performing the complete operation for cancer for doubtful benign lesions is unavoidable.

Among our 350 cases of chronic cystic mastitis, in 210—almost two thirds—the lesion was a distinct cyst, either with a blue dome, or one of the galactoceles type. I hope that my description and illustrations will help operators and pathologists to recognize this type and at least save two thirds of the patients with chronic cystic mastitis from the unnecessary removal of one or both breasts.

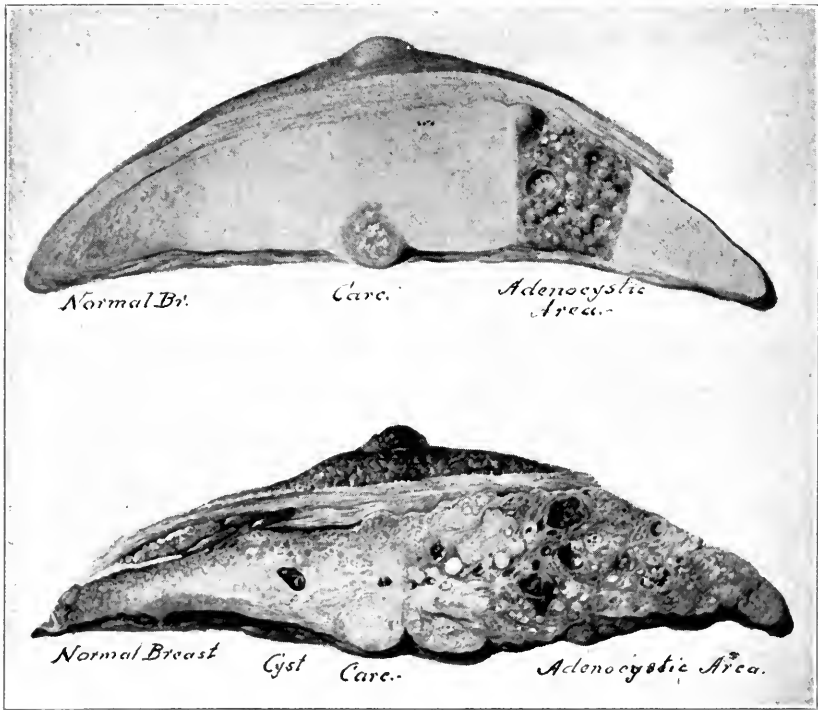


Fig. 23 (Path. No. 3965. BB-13-8 [B]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic adenomatous type. Copy of an original painting of a fresh section through the breast. The involved right half of the breast shows multiple minute cysts with multiple papillomas. The area marked *Carc.* was then considered to be cancer. For microscopic appearance, see Figures 54 and 83—chiefly benign papillary cystadenoma. The zone of breast to the left is adenomatous with a few minute cysts. See page 530.

#### THE GROSS APPEARANCE OF CHRONIC CYSTIC MASTITIS

1. *The Blue-Domed Cyst in Chronic Cystic Mastitis (BB-12-1)* (Figs. 1 to 7).—Of all the gross types of chronic cystic mastitis this blue-domed cyst is the easiest to recognize and of the most frequent occurrence.

Figure 1 (Path. No. 25508. BB-12-1 [T]) is a reproduction of the photograph of an unopened blue-domed cyst and shows the surrounding breast tissue. The dome was situated directly beneath the subcutaneous fat.

*Clinical Note.*—This patient was a white woman, aged 39. The lump was accidentally felt in the right breast three weeks before operation. The patient was married; but there had been no pregnancies. The palpable lump in the right breast was in the midzone of the upper and outer quadrant, the size of a twenty-five-cent piece. It was freely movable, distinctly spherical and tense. On careful palpation, definite fluctuation was elicited. At my examination, I felt a second, smaller tumor in the midzone of the upper hemisphere. This lump was freely movable and tense, but of less definite spherical shape than the larger tumor. The skin and nipple were normal. The second tumor had not been felt by the patient. There was no pain or tenderness. The remainder of this, the right, breast and the other breast were normal on palpation.

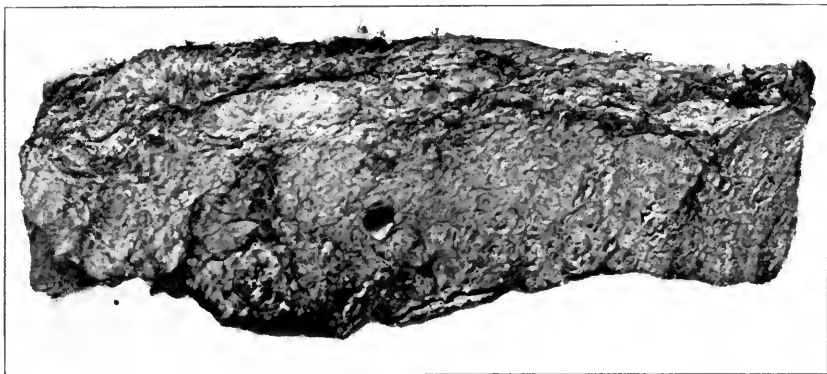


Fig. 24 (Path. No. 3965. BB-13-8 [B]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic adenomatous type. Section through the involved zone of breast after it had been hardened in liquor formaldehydi, showing chiefly minute cysts with papillomas. Result (1921): Well, twenty years after excision of the breast. See page 530.

*The palpation of two tumors in one breast, with the rarest exceptions, indicates benignity. In this instance, both tumors felt like cysts.*

At the exploration of the larger tumor, the blue dome of the cyst was immediately exposed after division of the subcutaneous fat and was excised with a zone of breast as shown in Figure 1. The second tumor could be palpated from the wound, and was also excised with a zone of breast. It also presented a distinct blue dome and was buried in breast tissue. In dividing the breast in excising these two tumors, no other cysts were encountered and no dilated ducts. The breast tissue was firm and white, with evidence of adenomatous hypertrophy.

On opening the smaller cyst, it was found to contain clear fluid. The cyst wall was smooth and thin.

On opening the larger cyst, after it had been in liquor formaldehydi and photographed, it was found that its contents had not coagulated (in the cysts of the galactoceles type the contents coagulate in the preservative).

*Microscopic Note.*—The breast tissue surrounding the cyst showed increase of fibrous stroma with many adenomatous areas and here and there a dilated duct. The cyst wall showed no epithelial lining, but in the wall there was lymphoid-cell reaction and adenomatous areas showing mastitis.

*Summary of Path. No. 25508.*—Clinically this case was considered benign on account of two palpable tumors. Each tumor on palpation suggested a cyst. Pathologically, two blue-domed cysts were found in a fibrous and adenomatous breast, with some evidence of mastitis.

*Result.*—One year after operation, the patient was well.

Figure 2 (Path. No. 27762. BB-12-1 [T]) is the reproduction of a photograph of an unopened blue-domed cyst and surrounding breast tissue. The thin zone of breast tissue covering the blue dome has been incised, enucleated from the cyst wall and retracted.

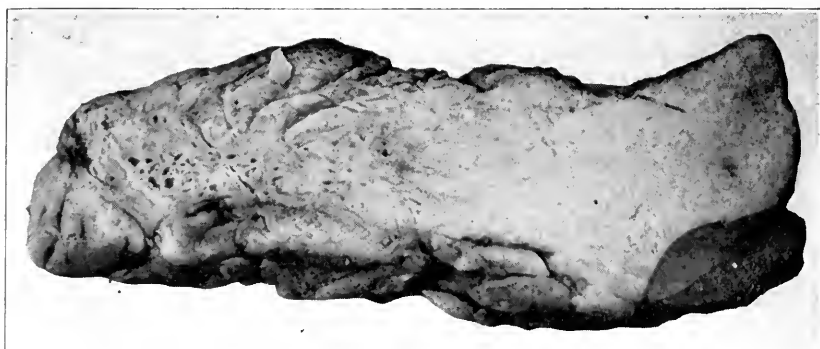


Fig. 25 (Path. No. 5221. BB-13-8 [CC]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type. Section through the breast. The left half shows minute cysts microscopically (Fig. 76) papillary cystadenoma; the right half is adenomatous. Specimen brought to the laboratory by Mr. Schloss, a third-year student. Result (1921): Well, seventeen years after complete operation for cancer. There was no metastasis to the axilla. See page 531.

*Clinical Note.*—The patient was a white woman, aged 51, unmarried. She was passing through the menopause. The periods had been irregular and scanty for three years. The lump was observed in the right breast three months before operation. There had been no pain. It had not varied in size, nor had there been the history of a disappearing lump. The tumor was in the upper and outer quadrant in the periphery of the breast, the size of a fifty-cent piece, freely movable, tense, smooth, like a cyst, and on most careful palpation showed slight fluctuation. The remainder of this breast and the other breast were normal on palpation.

*Diagnosis.*—Benign cyst.

*Operation.*—After dividing the subcutaneous fat, white breast tissue was exposed. The cyst could be palpated beneath. About 2 mm. of breast tissue was divided; and then the blue dome was clearly exposed. The palpable tumor was excised with a zone of breast tissue. In making this excision of breast tissue, two minute blue-domed cysts were exposed and removed. The remaining breast was adenomatous.

Figure 3 (Path. No. 27762) is a section through this blue-domed cyst and surrounding breast. The contents had not coagulated and were slightly cloudy. The wall of the large cyst was thin and smooth. In the illustration, the dark areas are minute blue-domed cysts; the gray areas are adenomatous, and the white areas fibrous breast stroma. There were no dilated ducts.

*Result.*—Two months after operation the patient was well.

Figure 4 (Path. No. 25560. BB-12-1 [CC]) illustrates a blue-domed cyst surrounded by fatty senile breast. The picture is of the posterior surface, as the cyst rested on the pectoral fascia and was covered with a thin zone of senile, fatty breast.



Fig. 26 (Path. No. 26439. BB-13-8 [CC]).—Section through the breast shows that the entire breast is involved—chiefly minute cysts with papillomas. For microscopic picture, see Figures 33 and 56. This case was diagnosed clinically (Bloodgood) in July, 1920, and the complete operation performed by Dr. Seegar at St. Agnes Hospital. The glands showed no metastasis. Result (1921): Well, one year later. See page 537.

*Clinical Note.*—The patient was a white woman, aged 65, who had passed the menopause many years before. Her attention was directed to the right breast by pain; and she felt a little lump in the periphery of the upper and outer quadrant. This patient had read of the importance of an immediate examination of a lump in the breast and was examined by my colleague Dr. Nichols, who felt the lump. At my examination, I could palpate a rather indefinite lump in the periphery of the upper and outer quadrant of the right breast. The lump did not feel larger than a ten-cent piece: it was buried deeply. Both

breasts were large and fatty, and there were no other lumps, nor indefinite indurated areas. The lump gave the sensation of being spherical and tense and suggested a cyst.

At this age, 65, so many years after the menopause, and in a distinctly fatty and senile breast, the benign cyst is rare, and cancer is the most frequent tumor. However, both Dr. Nichols and I were inclined to the diagnosis of a benign cyst.

*Operation.*—After dividing a great deal of subcutaneous fat, in which I could recognize only fibrous strands of breast stroma, I did not expose the tumor. Yet, I could palpate it indefinitely in the deeper tissue. After having made quite a deep wound, I came to the conclusion that it would be wiser to perform the complete operation for cancer. No glands were seen or felt in the axillary dissection.

*Gross Pathology.*—Figure 4 illustrates the blue-domed cyst which I exposed after operation. Later when the cyst was opened, it was found to contain a

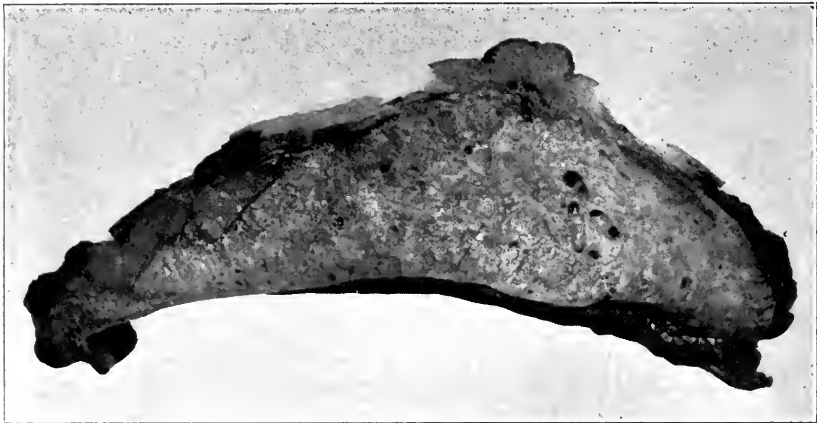


Fig. 27 (Path. No. 26046. BB-13-8 [BB]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type, involving both breasts. Section through both breasts. For microscopic appearance, see Figures 39, 40, 41 and 42. Result (1921): Well, one year after excision of both breasts. See page 536.

cloudy fluid (not coagulated) and a smooth, thin wall. The breast was fatty, with here and there remains of fibrous stroma. Beneath the nipple, there were a few dilated ducts without contents.

*Microscopic Pathology.*—The cyst wall had no epithelial lining. The breast was composed chiefly of fibrous tissue and fat, with here and there a few senile adenomatous lobules and slightly dilated ducts.

*Result.*—One year and three months after operation, the patient was well.

*Comment.*—I am now inclined to the opinion that in this case it would have been justifiable, after the exploratory incision at the point where I stopped, to excise a large zone of fatty breast tissue surrounding the palpable lump, to pack the wound with a gauze sponge saturated in 50 per cent. zinc chlorid solution, and then to explore the tumor. But I was influenced by the rarity of the blue-domed cyst after the menopause.

Figure 5 (Path. No. 10940. BB-12-1 [T]) is the reproduction of a photograph of a section through a blue-domed cyst and the surrounding breast tissue. One can see in the surrounding breast a few dilated ducts. This photograph was taken eleven years ago and represents the first satisfactory picture. At that time, I did not feel justified in excising a blue-domed cyst unopened. Now my evidence convinces me that the blue dome is so characteristic of benignity that one may excise it with a zone of breast tissue unopened, for teaching purposes. It retains its color even in liquor formaldehydi for some days, but loses it the moment it is opened. I have been able to demonstrate the blue dome in excised specimens to a very large number of medical students and postgraduates in the last few years; and these surgeons and students, I am confident, will be able to recognize this typical benign tumor at the exploratory incision. In fact, one of the third-year students who was present at an operation for a breast tumor, performed by a surgeon in his home state, pointed out the blue dome to the

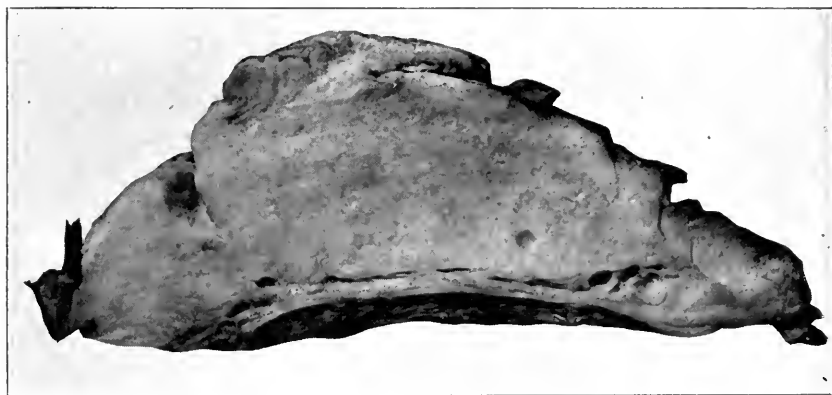


Fig. 28 (Path. No. 14115. BC-4; BB-13-8 [CC]).—Carcinoma and diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type. The entire breast is involved; section through breast showing a few minute cysts, many minute cysts with papillomas, great increase of adenomatous areas, and fibrous stroma. For microscopic appearance, see Figures 88 and 89, which show areas of carcinoma. The glands showed metastasis. The complete operation for cancer was performed by Dr. Finney in 1913 because of the diffuse induration of the breast and marked enlargement of the glands. Result: Death of metastasis to the brain in ten months. See page 537.

operator and apparently was the chief factor in preventing the complete removal of the breast. This specimen is in the laboratory, and its benign character has been confirmed. I have received specimens from three surgeons whom I had instructed on this tumor and who at an exploratory operation recognized the blue dome, excised the cyst with surrounding breast tissue and sent the specimen and history to my laboratory for confirmation of their diagnosis.

*Clinical History.*—This case is of particular interest, because, in 1910, I excised the blue-domed cyst shown in Figure 5 from the right breast and three years later removed a similar blue-domed cyst from the left breast. It is now (1921) eleven years since the first operation and eight years since the second, and there has been no recurrence. When this patient came under my observation in 1910, she was 38 years of age, and the irregular and scanty menstrual periods gave evidence that she was at an early menopause. She had observed pain and a tumor for three weeks. The tumor was in the midzone of the upper and outer quadrant, the size of a fifty-cent piece. It was freely movable, tense and spherical, and gave to the palpating fingers the sense of indefinite fluctuation. The remainder of this breast and the other breast contained many indefinite irregular nodules.

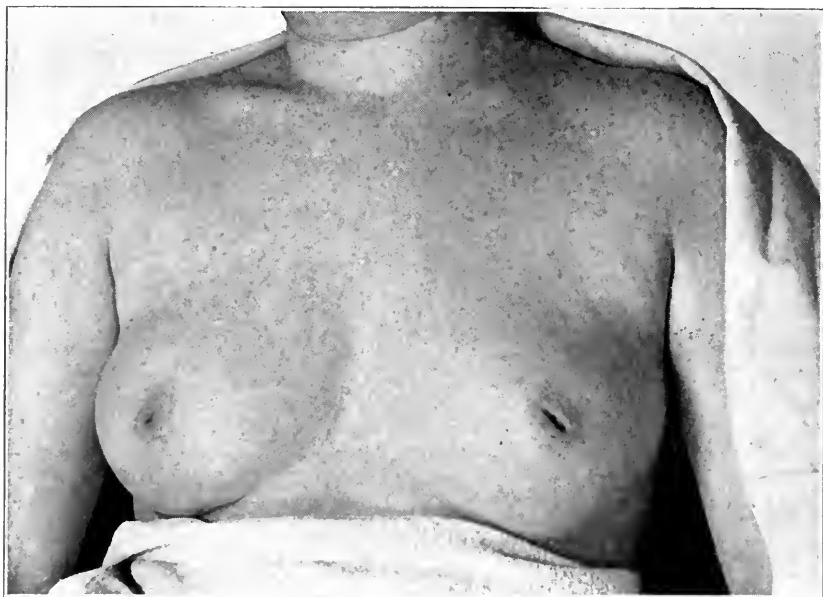


Fig. 29 (Path. No. 12586. BB-13-8 [CC]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type, showing retraction of left nipple, which had been permanent four months, intermittent for four years. There had been intermittent retraction of the right nipple for four months. Complete operation for cancer on both breasts (Bloodgood). No metastasis to the axilla. For microscopic appearance, see Figures 84 and 85. Result (1921): Well, nine years later. See page 534.

It is very important to note here that the palpation of multiple indefinite nodules in both breasts is very suggestive that the definite tumor is benign.

*Operation.*—My original notes, in 1910, describe a blue dome after division of the subcutaneous fat. It was about this time that I was beginning to believe that a blue dome was characteristic of a benign cyst. Observations in the eleven years since then have confirmed this conclusion.

This cyst, when opened, contained a cloudy fluid; the wall was 2 mm. thick (Fig. 5) and smooth. Here and there in the smooth wall of the cyst,



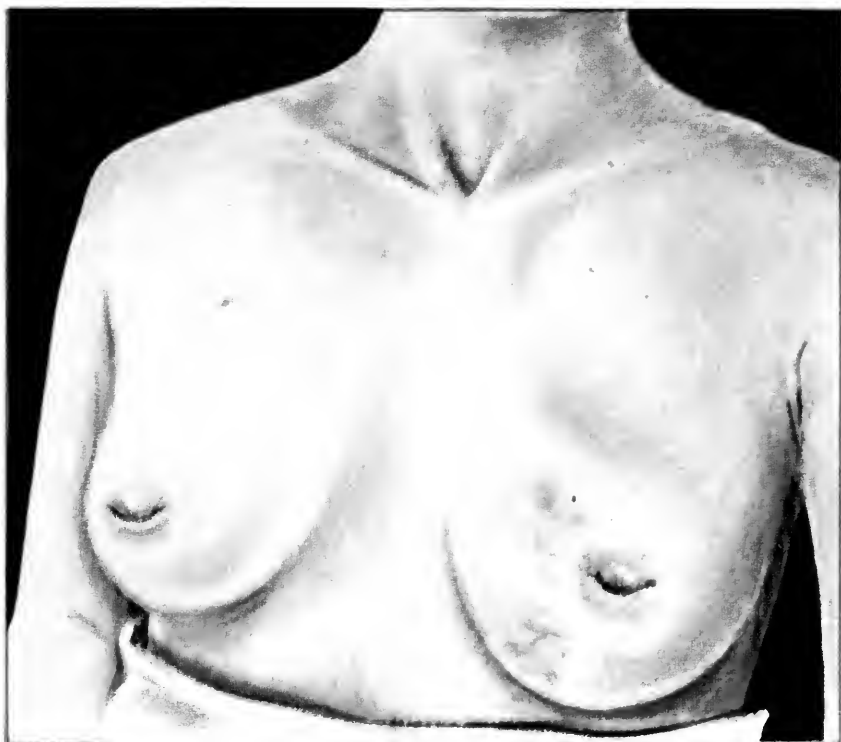


Fig. 30 (Path. No. 11125. BB-13-8 [CC]).—Diffuse nonencapsulated cystic adenoma with the picture of cancer clinically. Copy of painting, showing the bulging tumor, red and infiltrated skin. For gross appearance, see Figure 31.

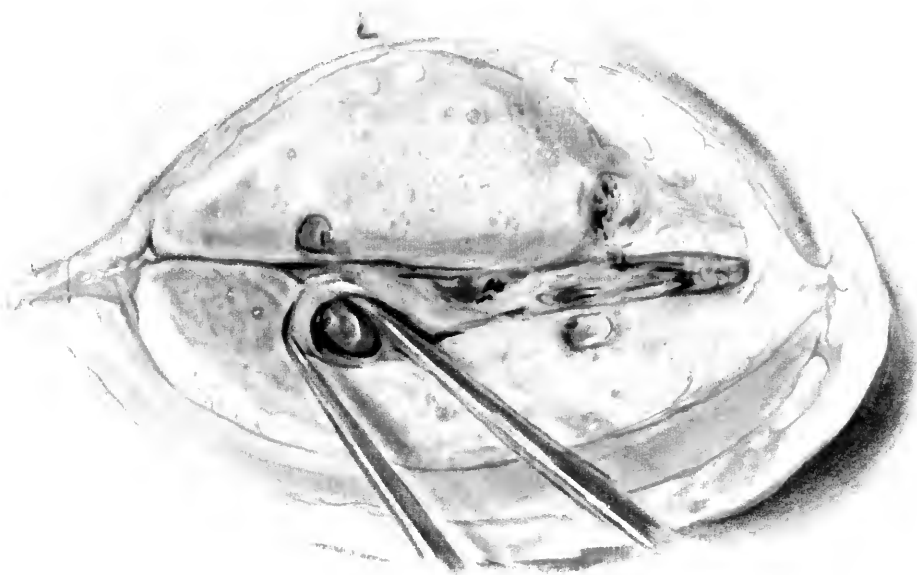


Fig. 31 (Path. No. 11125. BB-13-8 [CC]).—Diffuse nonencapsulated cystic adenoma with infected cyst producing the clinical picture of cancer (see Fig. 30). Result: Well, ten years after complete operation for cancer.



one could recognize little brown macular areas. Recent microscopic studies have demonstrated that this discoloration is due to minute hemorrhages into the cyst wall (Fig. 46). However, I have never observed the contents of these benign blue-domed cysts to be smoky or hemorrhagic. This blood coloring, if there is no papilloma, is a sign of cancer.

In excising this cyst (Path. No. 10940), I encountered a few dilated ducts beneath the nipple from which could be expressed a creamlike material; and we could express the same material through the nipple. This had not been observed before operation.

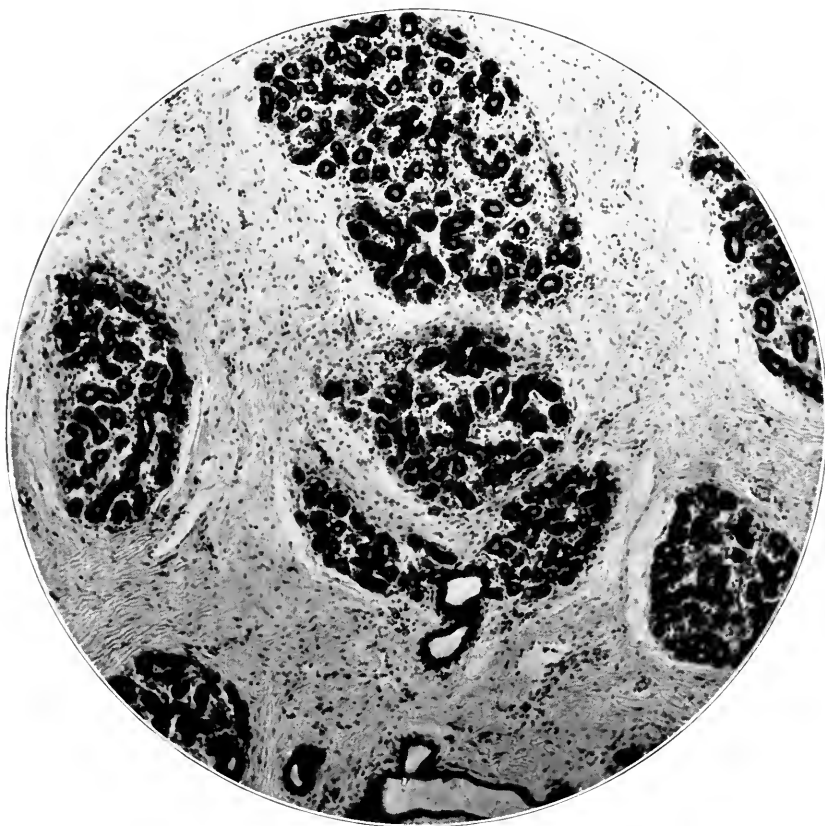


Fig. 32 (Path. No. 14156. BB-13-5 [T]).—Normal adenomatous puberty type of chronic cystic mastitis. Section from a nonencapsulated adenomatous nodule in the axillary portion of the breast. For gross appearance see Figure 14. Exploration (Bloodgood) May, 1913; excision of zone of breast only. Result (1921): Well, eight years later. See legend for Figure 72 and page 496.

I wish to emphasize this point here. The exposure of dilated ducts in dividing the breast to remove a blue-domed cyst is not an infrequent occurrence. The contents may be like milk or cream, brown or green. Their presence is *not* an indication to remove the breast.

At the second operation on this patient in 1913, the tumor in the left breast showed a blue dome. Its contents were cloudy, with white débris; and in removing the zone of breast with the cyst, two dilated ducts with milky contents were divided.

The microscopic sections from the breast tissue of both operations in this patient showed many areas of solid adenoma, which some pathologists would interpret in the frozen section as suspicious of malignancy, and advise the complete operation for cancer, or removal of the breast (Figs. 58, 59 and 60).

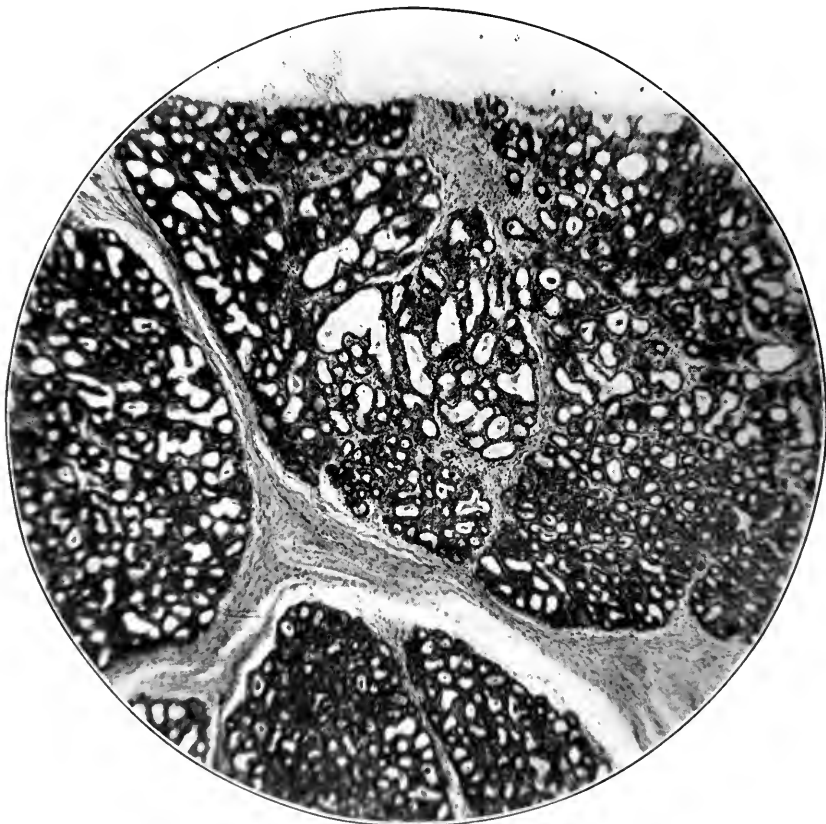


Fig. 33 (Path. No. 26439. BB-14).—Lactation hypertrophy in an encapsulated adenoma, removed from a lactating breast. See page 537.

Figure 6 (Path. No. 27007. BB--12-1 [T]) shows a section through a large blue-domed cyst and the surrounding breast. The cyst has a thin smooth wall, and the little brown macular areas in the surface of the cyst wall are shown. I have described them in the previous case (Fig. 5), and microscopic sections from Path. No. 27007 demonstrated that they were due to small areas of hemorrhage into the wall

of the cyst. The breast surrounding this cyst is chiefly fibrous and fatty. In the picture, the white areas are fibrous; and in this white area, fat can be seen. There is one dilated duct shown and one minute cyst. The adenomatous areas do not show in the illustration.

*Clinical Note.*—This blue-domed cyst is interesting because it was larger than usual, a little larger than a silver dollar. It was in the midzone of the outer hemisphere of the right breast and filled a quadrant of the breast. The size made me suspect a malignant tumor—either a cancer cyst or a medullary carcinoma. The tumor, however, was smooth, tense, and somewhat spherical.

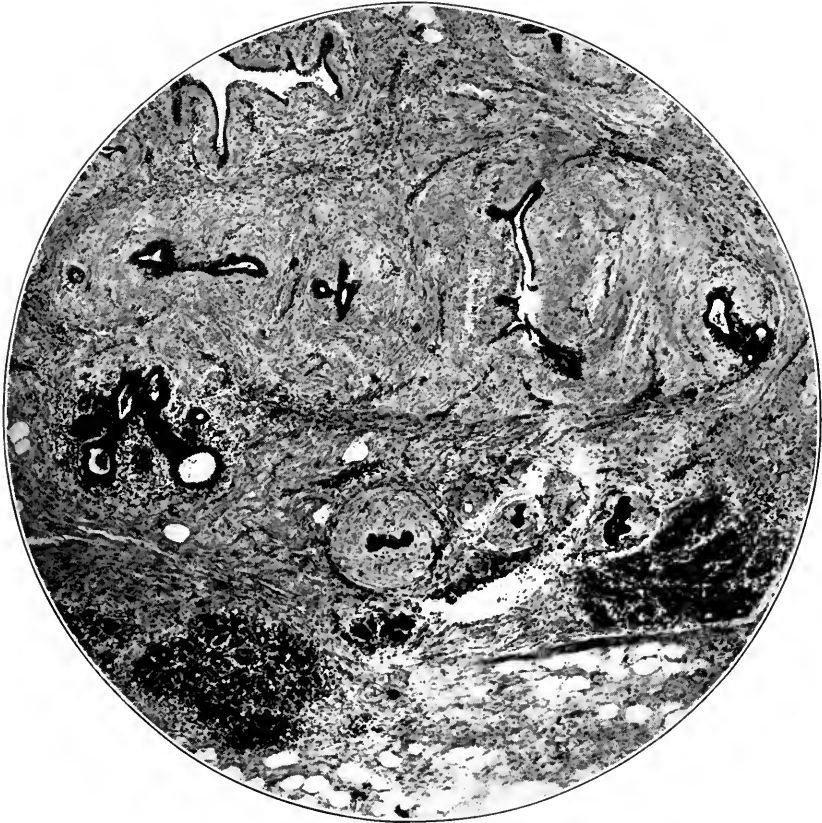


Fig. 34 (Path. No. 19982. BB-7).—Section illustrating the picture of a senile breast taken from a nonencapsulated area which had remained unresolved eleven years after the last lactation. The mastitis had not resulted in abscess. The thick-walled ducts indicate the old mastitis, otherwise the section resembles the senile breast. Result (1921): Well, five years after the excision of a zone of breast.

There was distinct fluctuation. It is important to note that a medullary carcinoma or a cancer cyst may give the sensation of fluctuation. I found, however, in addition, multiple indefinite nodules in the remaining portion of the right and in the left breast. This finding favored a benign cyst.

The patient was 45 years of age, and had had one child with normal lactation. The lump had been discovered accidentally nine weeks before operation, and the patient had noted no increase in size. If her observation was correct, this suggested a benign cyst. Only this type of breast tumor can reach such a size in such a short time and then remain stationary. The patient had not observed any variation in size. The skin and nipple were normal. My clinical diagnosis was benign cyst.

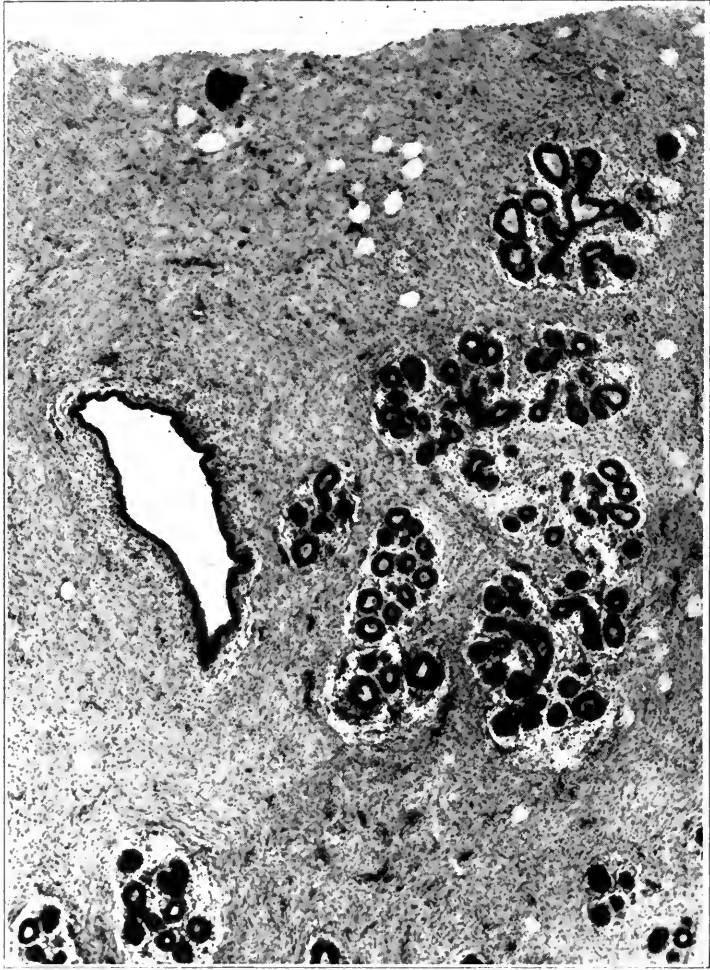


Fig. 35 (Path. No. 6686. BB-13-4 [T]).—Fibro-adenomatous area in section from a nonencapsulated adenoma excised with a zone of breast by Dr. Finney in 1905. For gross appearance, see Figure 13. Result (1921): Well, sixteen years later.

*Operation.*—The typical blue dome was exposed the moment the subcutaneous fat was divided; but on account of the size of the cyst, I immediately

opened it. Its contents were cloudy fluid. I then made a frozen section and found no evidence of malignancy in the cyst wall.

*Result.*—Five months after operation, the patient was well.

Figure 7 (Path. No. 21770. BB-12-1 [T]) is the reproduction of a photograph of a blue-domed cyst and surrounding breast tissue.

Figure 8 shows a section through the specimen shown in Figure 7, illustrating two blue-domed cysts with surrounding breast. The breast is very adenomatous with a few minute cysts.

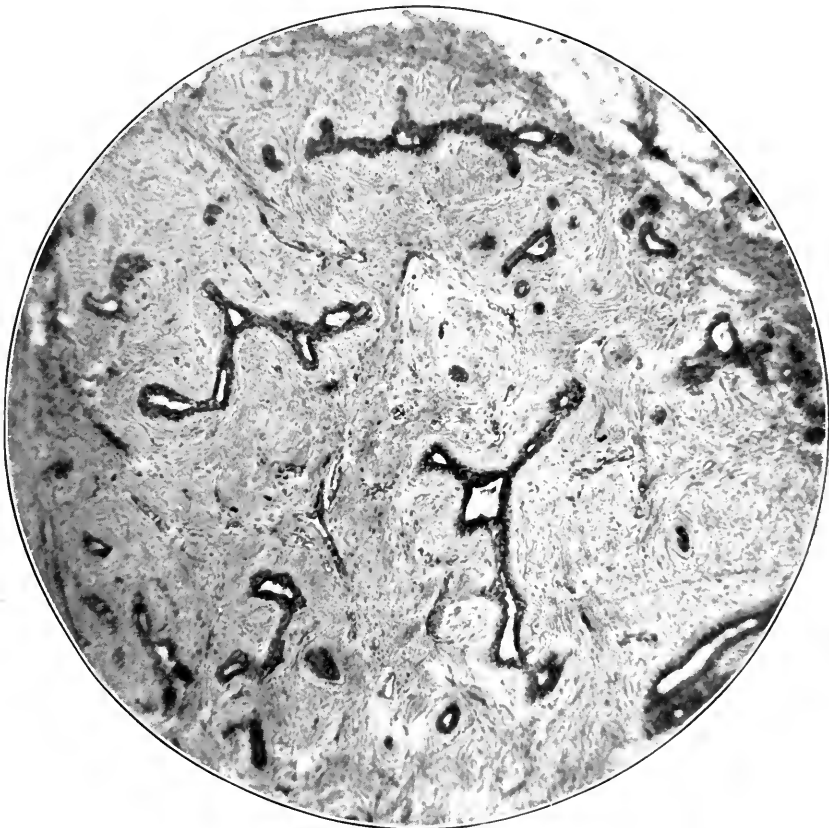


Fig. 36 (Path. No. 8717. BB-12-3 [B]).—Intracanalicular-adenomatous area in a breast containing multiple blue-domed cysts. Result (1921): Well, fifteen years after excision of the breast (Bloodgood).

*Clinical Note.*—This patient was a white woman, aged 29. Six years previously I had removed a similar blue-domed cyst from the right breast; she was then 23, and represented one of the youngest patients in this group. There had been no recurrence in the right breast; but she had observed a lump in the upper and outer quadrant of the midzone of the left breast. The lump was about the size of a twenty-five-cent piece, tense and smooth, slightly lobular,

suggesting an adenoma, or two cysts. Both breasts contained indefinite multiple nodules which had not been noted at the previous examination six years before.

*Operation.*—After dividing the subcutaneous fat, a typical blue dome was exposed. In excising the tumor with a zone of breast, the breast tissue was found to be very adenomatous; and between the tumor and the nipple, I divided two dilated ducts filled with grayish-brown pastil material.

*Microscopic Pathology* (Fig. 47).—You will observe from this section that the breast surrounding the blue-domed cyst shows the papillary cystadenoma of chronic cystic mastitis, which is less frequently found to such an extent about



Fig. 37 (Path. No. 16133. BB-12-1 [T]).—Aberrant-adenomatous area in the wall of a blue-domed cyst. Result (1921): Well, seven years after excision of the cyst with zone of breast.

the blue-domed cyst, but is more characteristic of the type usually called Schimmelbusch's or Réclus's disease (BB-13-8).

*Result.*—Ten years after the first operation and four years since the second (1921), there was no recurrence.

It is interesting to note that this patient's sister had a similar condition in both breasts for which both breasts were completely removed. The tissues from these two operations were sent to my laboratory.



2. *Cysts of the Galactocoele Type (BB-12-2).*—These cysts differ from the blue-domed cysts in the absence of a *blue* dome. The dome is opaque white, and when opened the contents are milky. These cysts can be distinguished from the true galactocoele, because they have been observed in women who have never been pregnant, and the surrounding breast shows no gross or microscopic evidence of lactation hypertrophy.

In a few instances, I have observed this cyst alone in the breast. More frequently it has occurred as a smaller second cyst exposed in



Fig. 38 (Path. No. 16392. BB-12-1 [T]).—Irregular adenomatous area with a slightly dilated duct, showing duct adenoma. Section from the wall of a blue-domed cyst. Result (1921): Well, seven years after excision of the cyst with zone of breast.

excising a typical blue-domed cyst. I have already noted that the dilated ducts in chronic cystic mastitis may contain creamlike or milklike contents (Fig. 5), which cannot be distinguished in the gross from the dilated ducts filled with milk in the galactocoele. The contents of the cyst of the galactocoele type coagulate when placed in alcohol or

liquor formaldehydi. The contents of the blue-domed cyst do not coagulate, as already noted. The chemistry of the contents of this cyst of the galactoceles type I have not studied. The microscopic appearance of its wall and the surrounding breast does not differ from that of the blue-domed cyst. Therefore, the cyst of the galactocela type and dilated ducts filled with milklike or creamlike contents is one of the gross findings of chronic cystic mastitis, and it has no relation to lactation.

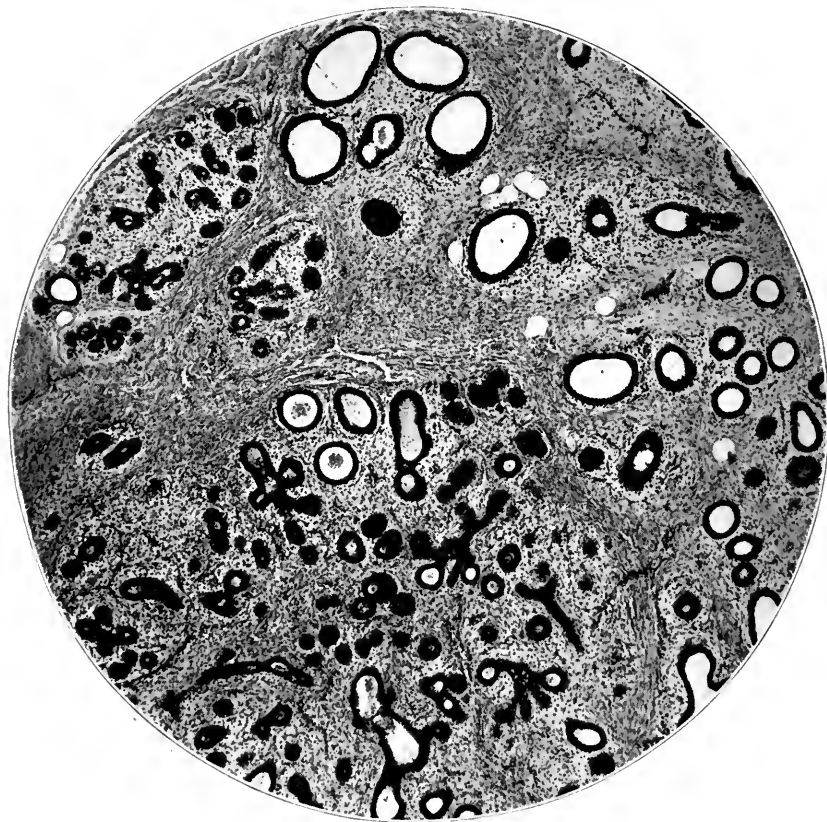


Fig. 39 (Path. No. 26046. BB-13-8 [BB]).—Cystic-adenomatous area with some small solid alveolar adenomas. Section from breast, the seat of diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type. For gross appearance, see Figure 27; see also Figures 40, 41 and 42, and page 536.

Figure 9 (Path. No. 26803. BB-12-2 [T]) is the reproduction of a photograph of a section through a cyst of the galactocela type and the surrounding breast.

This specimen was excised and sent to my laboratory unopened for diagnosis. The coagula filling the cyst may be noted. The sur-

rounding breast shows no other cysts or dilated ducts and is composed of a mixture of fat and fibrous breast tissue with numerous adenomatous areas. The illustration, however, shows a few dilated ducts not noted in the description of the gross specimen. The specimen sent to the laboratory was the size of a silver dollar, and I could palpate in the center a spherical tense tumor. On incision, the dome was white, not blue. The cyst wall was a little thicker than usual, 3 mm.; the cyst was small, the size of a 5-cent piece; its contents were milklike and coagulated.



Fig. 40 (Path. No. 26046. BB-13-8 [BB]).—Section showing epithelium-lined cysts, cystic adenoma, small solid adenoma, large duct adenoma, and mastitis. See page 536.

*Clinical Note.*—The patient was a white woman, aged 23, and had been married one year and seven months without pregnancy. Her breasts had always been tender just before the menses. Five weeks before operation, just before her menses, the right breast was more tender than usual, and she felt a lump the size of a walnut. She immediately consulted her physician who referred her to Dr. A. P. Butt of Davis, W. Va.

The latter excised the palpable lump with a zone of breast tissue and sent it to the laboratory for diagnosis.

*Microscopic Pathology.*—There was no epithelial lining of the cyst wall. In the surrounding breast, there were a few dilated ducts, cystic adenomatous areas, and here and there ducts and acini plugged with proliferating cells.

*Result.*—Six months after operation, the patient was well.

Figure 10 (Path. No. 25517. BB-12-2 [T]) shows a section through a cyst of the galactocele type and the surrounding breast. In

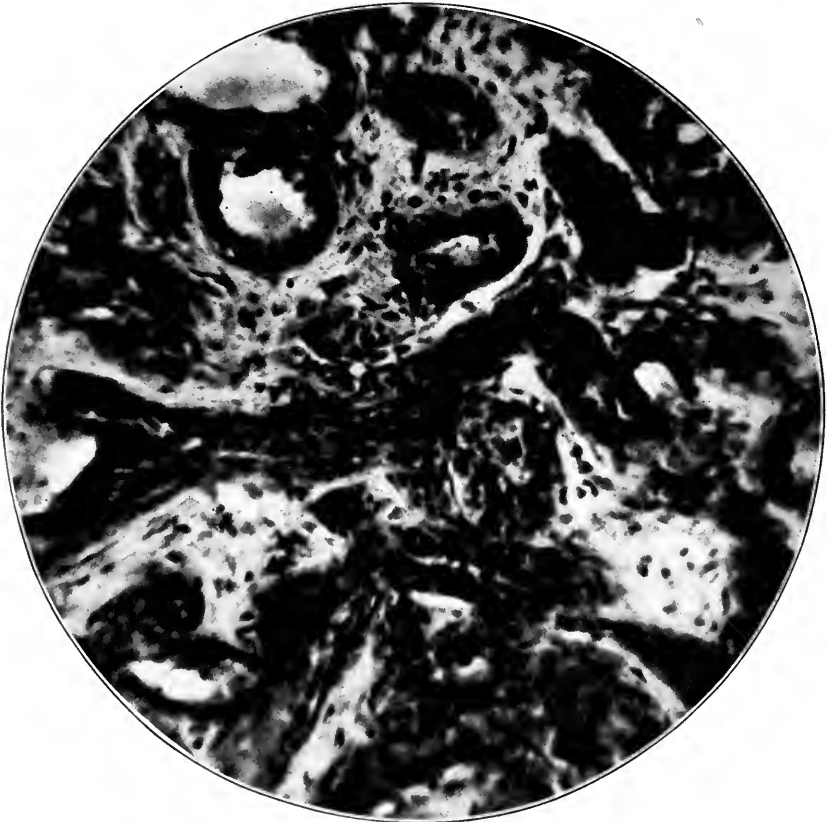


Fig. 41 (Path. No. 26046. BB-13-8 [BB]).—Section showing nonencapsulated diffuse cystic adenoma. High power magnification of irregular stellate solid adenoma. See page 536.

addition, one sees a small dilated duct; the breast was very adenomatous, and there was even gross evidence of chronic mastitis.

*Clinical Note.*—The patient was a white woman, aged 43. A lump was accidentally discovered four months ago in the left breast. At that time the entire breast was sensitive and apparently swollen. This symptom of onset of breast tumor I have called mastitis. It is not a frequent occurrence. The

clinical picture is similar to that of the "caked" breast of lactation. I have observed it chiefly in chronic cystic mastitis, rarely in comedo-adenoma and never in cancer.<sup>1</sup>

In this case, in a few days, the mastitis subsided and a small lump could be palpated in the periphery of the upper and outer quadrant. The lump was freely movable and the size of a twenty-five-cent piece. It was tense and spherical and suggested a cyst buried in breast tissue. The remainder of this and the other breast were normal on palpation. Her husband, a surgeon, was confident that the palpable tumor had varied in size. This is almost a positive

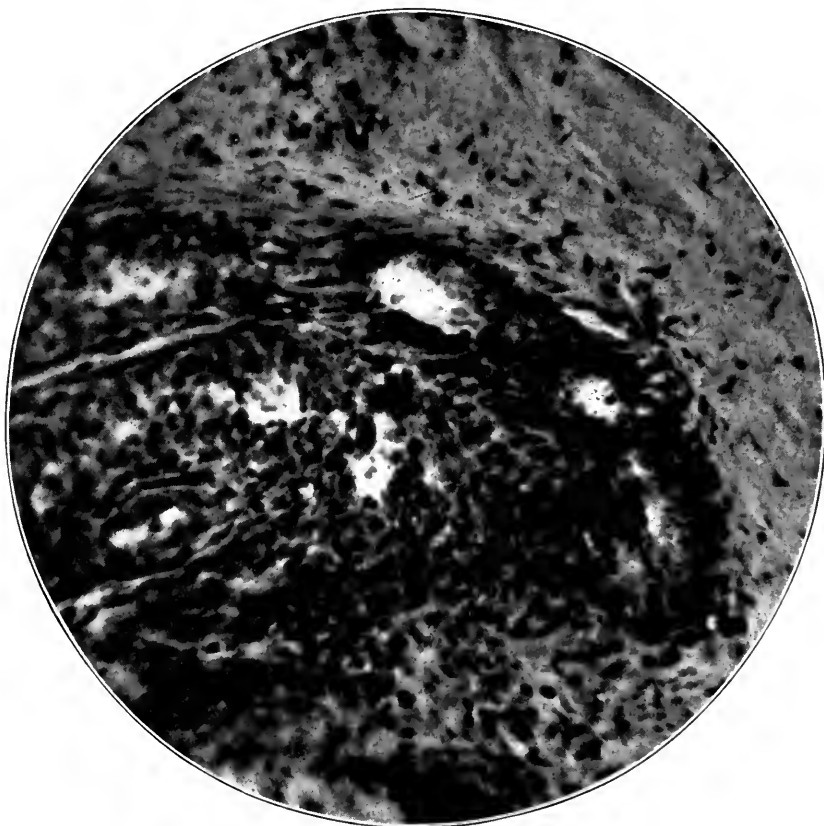


Fig. 42 (Path. No. 26046. BB-13-8 [BB]).—Section of diffuse nonencapsulated cystic adenoma. High power magnification of large solid duct adenoma. See page 536.

sign of a benign cyst. There had been but one child; but there was no milk in this breast. I had observed this patient four years previously because of a painful breast; but nothing could then be made out on frequent examinations.

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1. A restudy of so-called acute carcinoma of the breast may reveal a few cases in which the onset suggested mastitis, but so far no example has been found.

*Operation.*—On dividing the subcutaneous fat, firm white breast tissue was exposed. On dividing about 4 mm. of this breast tissue, no blue dome was found, but a white opaque dome suggesting a galactocele. On incision, the wall of the cyst was a little thicker than usual, and its contents resembled milk. In excising the breast tissue to remove the tumor, numerous adenomatous areas were encountered, but no other cyst or dilated duct. A minute cyst is seen in the illustration (Fig. 10).

*Microscopic Pathology.*—The cyst wall had no epithelial lining and was a little thicker than usual (Fig. 44). There was evidence of chronic inflammation, a few minute epithelium-lined cysts, adenomatous areas with ectasia, a few

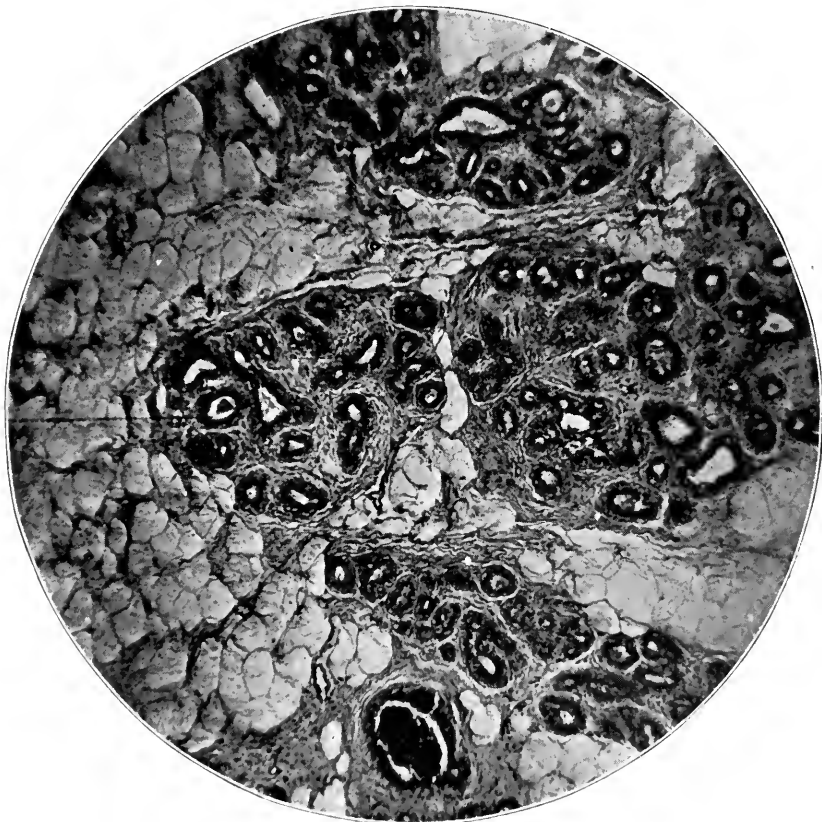


Fig. 43 (Path. No. 8717. BB-12-3 [B]).—Cystic-adenomatous area (ectasia) from the wall of a blue-domed cyst. Breast contained multiple blue-domed cysts (See also Fig. 36).

dilated ducts, adenomatous areas with mastitis, and some adenomatous areas in which the acini were plugged with cells and which might be considered by some pathologists as suspicious of cancer (duct adenoma, Fig. 59).

*Result.*—Two years (1921) after operation, the patient was well.

3. *Multiple Blue-Domed Cysts. BB-12-3.*—The multiple cystic disease of the breast, usually bilateral, is a less frequent occurrence than

the single blue-domed cyst. The only difference in the pathology is that the breast is riddled with cysts of various types, usually blue-domed, but some—the smaller—may be of the galactoceles type.

In the few cases observed by me, there have always been, clinically, multiple tumors in both breasts, and the condition has been recognized clinically. Formerly, I excised both breasts; recently, I have not subjected these patients to operation at all—a point which will be discussed in the second paper again.

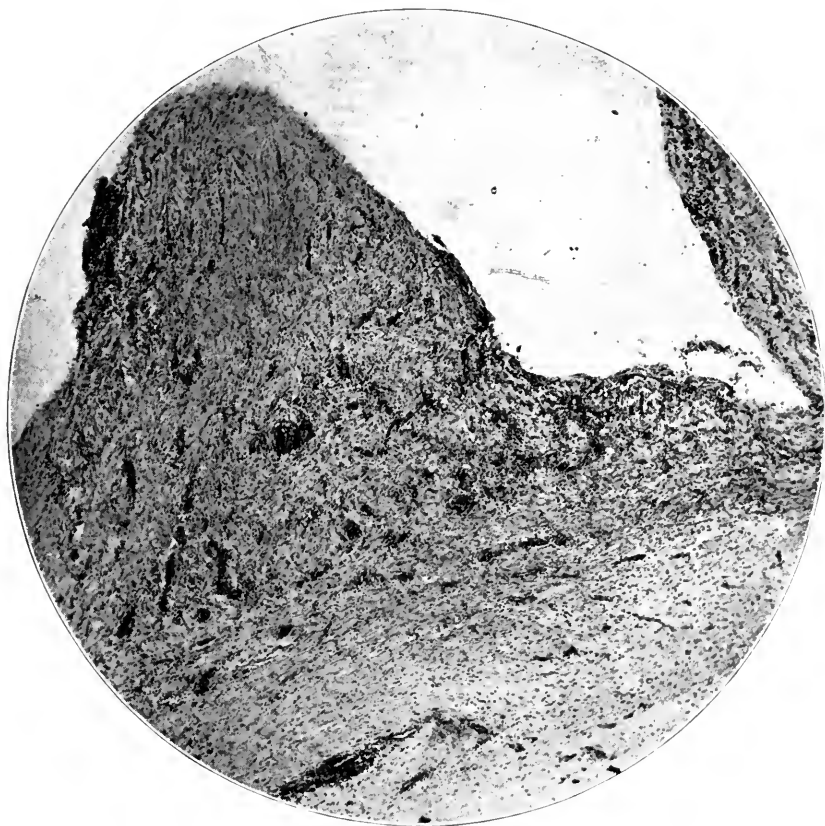


Fig. 44 (Path. No. 25517. BB-12-2 [T]).—Section from the wall of a cyst of the galactoceles type; no epithelial lining; wall thickened by chronic inflammatory tissue. For gross appearance, see Figure 10. Result (1921): Well, one year after excision. See page 486.

Figure 11 (Path. No. 26139. BB-12-3) illustrates sections through both breasts after preservation in liquor formaldehydi. One will observe that the gross character of the larger cysts resembles the single cyst illustrated in Figures 3 and 8; that in the breast tissue surrounding these larger cysts, there are more smaller and minute cysts than in the

breast tissue surrounding the single blue-domed cysts in Figures 3, 6 and 8. The breast tissue itself—not cystic—does not differ from the breast tissue illustrated in Figures 3, 6 and 8.

In this case, the breasts were sent to me by Dr. Royster of Raleigh, N. C., with a note that they were removed from a mulatto woman, aged 39. There were multiple palpable tumors in both breasts, but other details of the history were not obtained.

*Microscopic Pathology* (Fig. 48).—The most interesting feature is that almost every epithelium-lined duct or acinus of these breasts showed dilatation of varying degrees. The epithelial cells lining the dilated ducts and acini showed proliferation and degeneration. Papillary cyst-adenomatous areas, so characteristic of the group BB-13-7 type, are practically absent.

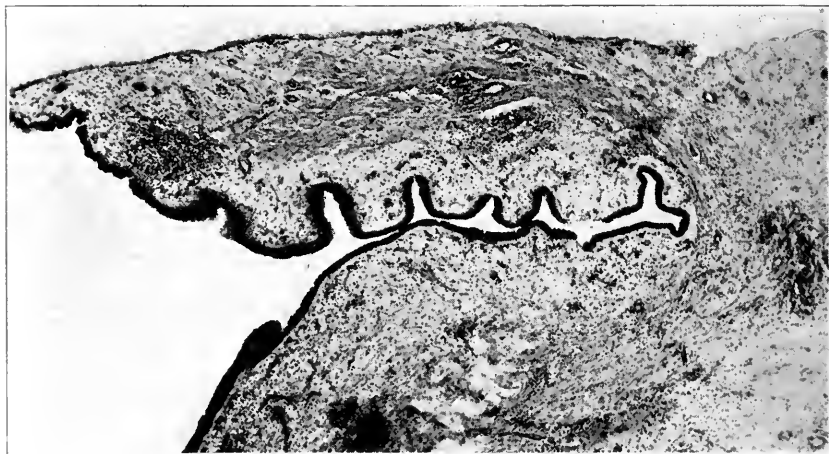


Fig. 45 (Path. No. 27346. BB-12-1 [T]).—Section from a portion of the wall of a blue-domed cyst showing the remains of the epithelial lining and suggesting that the cyst originated in a duct. Result (1921): Well, six months after excision of the cyst and zone of breast.

Figure 12 (Path. No. 4903. BB-12-3) shows a section through the right breast removed in 1903, almost twenty-one years ago, by Dr. Follis at Johns Hopkins Hospital. According to the history, the patient had observed only one tumor in the right breast, of but two weeks' duration. At the examination, it is noted in the history, there was one tumor in the right breast to the outer side of the nipple and a smaller tumor in the same position in the left breast. From the right nipple a few drops of slate-colored fluid could be expressed.

The patient was 39 years of age, and gave the history of a miscarriage fifteen years before observation; there were no other pregnancies, no lactations.



In the laboratory, we could palpate multiple tumors in the right breast. As one cyst could be palpated in the left breast, it is fair to assume that this breast was similarly affected. Nevertheless, at the present time this breast is normal.

This and other observations have led me to conclude that there is no relation between single and multiple blue-domed cysts and the cysts of the galactocele type and carcinoma. If the exploratory incision reveals a cyst of this character, there is apparently no necessity for removing one or both breasts.

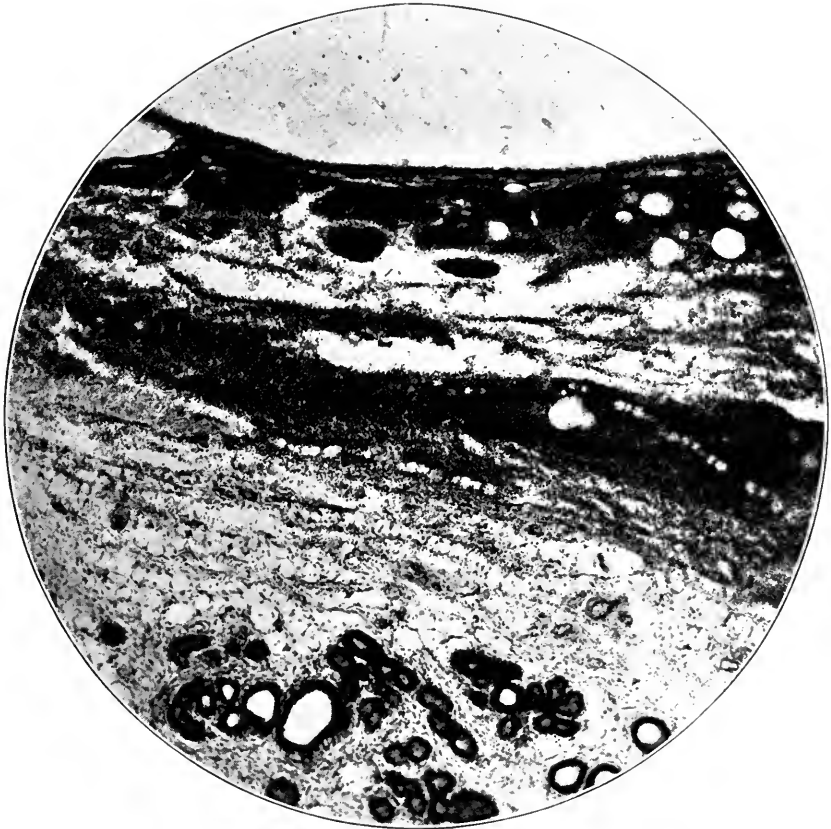


Fig. 46 (Path. No. 26650. BB-12-1 [T]).—Section from the wall of a blue-domed cyst; epithelial lining; dark areas beneath the lining are areas of hemorrhage. (For gross appearance, see Figure 6.) The next zone is granulation tissue, the next contains an area of cystic adenoma. This tumor was of only four days' duration. The cyst contained cloudy fluid, no blood. Result (1921): Well, one year after excision of the cyst and zone of breast. See page 475.

4. *The Nonencapsulated Adenoma in Chronic Cystic Mastitis (BB-13-4).*—In this type, in the explored palpable area there are no visible

cysts or dilated ducts. I first became familiar with its gross appearance in a group of aberrant, encapsulated, benign breast tumors which are observed in young girls at, or shortly after, puberty, and have been classed with fibro-adenoma.

Then, many years ago, before I had the evidence that there was little or no relation between chronic cystic mastitis and carcinoma, I removed both breasts from a patient, aged about 45, because of multiple indefinite nodules in both breasts, of a few months' duration. This was about the time of Warren's publication from Boston; and this case



Fig. 47.—(Path. No. 21770, BB-12-1 [T]).—Section of breast tissue from the wall of a blue-domed cyst. Group of small cysts lined by columnar epithelium; dilated duct; irregular cystic adenoma; lobules of mastitis. See Figures 7 and 8. For microscopic picture of another area, see Figure 55. Result (1921): Well, four years after excision of cyst and zone of breast. See page 480.

seemed to correspond to the bilateral lesion of the breast which he called the "cobble-stone" breast.

When these two breasts were examined, there were no dilated ducts and no cysts, even minute; but each little palpable indefinite nodule could easily be recognized from the surrounding fibrous and fatty breast by a group of elevated pink dots. I have a painting of this specimen; but it is not good enough for reproduction.

Studied microscopically, each of these nonencapsulated areas showed an increase of the parenchyma—a microscopic condition which I have called *adenomatous* (Figs. 32 and 35).

My observation, after the pathologic examination of this case, led me to the conclusion that operation was not indicated in a condition of this kind, when there was nothing to be made out but multiple indefinite nodules in both breasts.

At the present writing I have a record of forty-eight cases with a similar clinical picture in which no operation has been performed. All these patients have been followed, and the multiple indefinite nodules

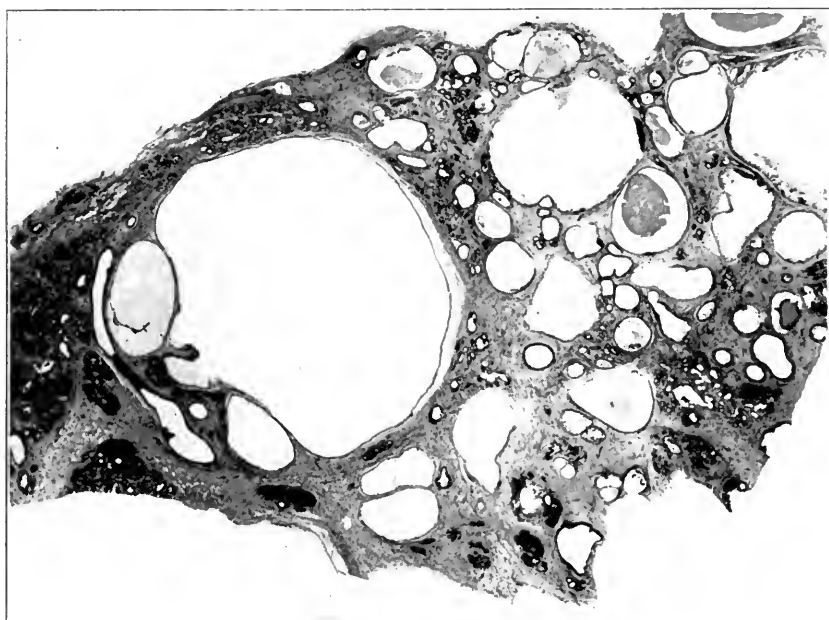


Fig. 48 (Path No. 26139. BB-12-3 [BB]).—Section from breast riddled with multiple blue-domed cysts of all sizes. Both breasts were involved and removed. For gross appearance, see Figure 11; also see page 488.

ultimately disappeared. Apparently, patients in this group run no more, and perhaps less, risk of a cancer of the breast than women at the same age whose breasts are normal on palpation.

Figure 13 (Path. No. 26695. BB-13-4 [T]) shows a gross section through the zone of breast removed. To the right, one sees a zone of breast which differs from the area to the left. In the area to the right, there is more white breast stroma embedded in which are small gray areas. These in the fresh specimen were pink. To the left, the breast has more fat, less stroma and fewer of these areas.

*Microscopic Pathology.*—The area shown to the right in Figure 13 is filled with irregular adenomatous areas somewhat resembling the benign encapsulated fibro-adenoma. There are no cysts and no dilated ducts. There are a few adenomatous areas with ectasia and a few minute epithelium-lined cysts and two ducts with minute papillomas (in a second section) and one duct with solid adenoma.



Fig. 49 (Path. No. 19994. BB-13-6 [BB]).—Section through zone of breast beneath nipple, showing diffuse dilatation of ducts. For gross appearance, see Figures 16, 17 and 20. Result (1921): Well, seven years later.

*Clinical Note.*—This patient was a single woman, aged 42. For one year she had been conscious of a small lump in the left breast. There had been no pain. She was still menstruating, apparently normally.

At my examination, I felt a lump, the size of the end of the index finger, in the midzone of the upper and outer quadrant. It corresponded to the lump the patient had felt. I could not palpate in the remainder of this breast, nor in the other breast, any other definite lumps or any area of abnormality. The little lump did not feel tense and spherical like a cyst, but had an irregular outline, and not the hardness of cancer.

At the exploratory incision, Sept. 9, 1920, after dividing the subcutaneous fat, I exposed white breast tissue; but the little lump was difficult to palpate. For this reason, I excised a zone of breast the size of a fifty-cent piece, half of which is shown in Figure 13. This, when sectioned, gave the appearance shown in Figure 13, already described. In cutting this zone of breast out, I encountered no cysts and no dilated ducts. The divided breast tissue was composed chiefly

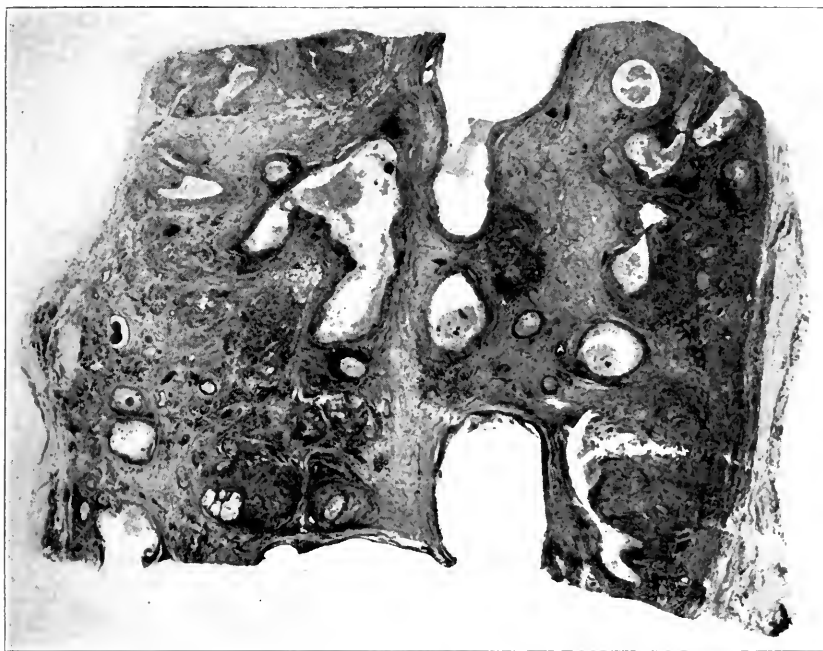


Fig. 50 (Path. No. 21192. BB-13-6 [CC]).—Section of diffuse dilatation of ducts with periductal mastitis involving a zone of breast. For gross appearance, see Figure 19 and page 511.

of fat, with here and there a fibrous strand of stroma. This picture is illustrated in Figure 13 to the left. The wound was then closed in the usual way.

*Result.*—This patient was well (April, 1921), seven months after operation.

This type, BB-13-4, the nonencapsulated adenoma, was rarely observed until patients were educated to seek advice quickly after the palpation of a lump in the breast. These observations seem to indicate that tumors of this character in the past have disappeared when the patients delayed examination. As noted before, I first observed them

as multiple indefinite nodules, and now, when they appear with this clinical picture, I advise against operation. As a single tumor, I first observed it in 1913, and since then the number has increased.

When the patient, 25 years of age or older, has but a single lump in one breast, operation is indicated at once, because there is no way, at least at the present time, to exclude the possibility of malignancy, except by an exploratory incision.

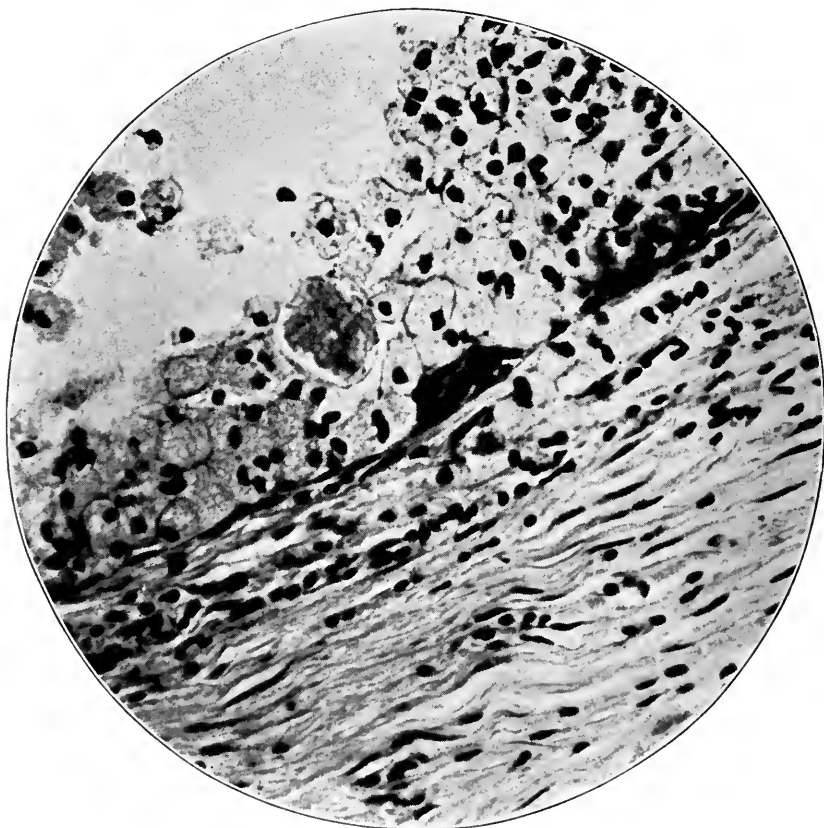


Fig. 51 (Path. No. 21192. BB-13-6 [CC]).—High power magnification of duct shown in Figure 50—desquamating, degenerating cells within the duct and mastitis in the wall. See page 511.

Figure 14 (Path. No. 14923. BB-13-4 [T]) is also a reproduction of a photograph of a zone of breast excised; but it shows the contrast between the nonencapsulated adenomatous area and surrounding breast tissue less distinctly than Figure 13. This is probably due to the fact that the patient was a young unmarried woman, aged 23, while the patient whose specimen is shown in Figure 13 was 42, and breast parenchyma was being largely replaced by fat, except in the tumor area.

*Clinical Note.*—A white unmarried woman, aged 23, complained of definitely localized pain in the axillary portion of the upper and outer quadrant of the left breast, of three and one-half months' duration. She had palpated the lump for one month.

At my examination in November, 1913, I could make out but one palpable area in the axillary portion of the upper and outer quadrant of the left breast. The remainder of this breast, and the right breast, were of the normal virginal

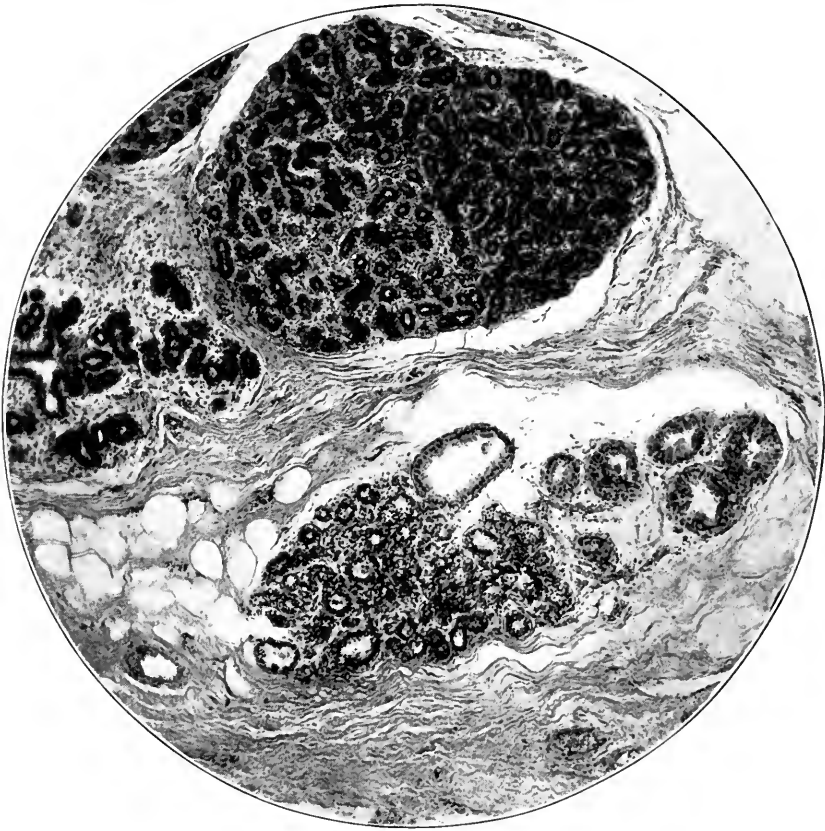


Fig. 52 (Path. No. 16133. BB-12-1 [T]).—Section from the wall of a blue-domed cyst. The lower lobule shows to the right the early stage of alveolar papillary cystadenoma. The left portion of the same lobule shows irregular adenoma with mastitis. The upper lobule shows an aberrant adenomatous area, the right lobule a fibro-adenomatous. Result (1921): Well, seven years after excision of the cyst.

type. The palpable area was indefinite, slightly nodular. It did not feel like an encapsulated tumor or a cyst; but I knew that encapsulated small adenoma buried in breast tissue gave this feeling on palpation.

I advised operation because the patient was about to be married, and as adenomas undergo lactation hypertrophy during pregnancy and may give trouble

by enlargement, it saves the patient discomfort and anxiety when the tumor is removed before this event.

*Exploratory Incision.*—The palpable area when cut into showed an increase of pink elevated dots as compared with the surrounding normal breast. The area was not encapsulated and was irregular in outline.

*Microscopic Pathology.*—The section showed chiefly adenomatous areas (Fig. 32). There was some ectasia, a little mastitis, and one area of cystadenoma.

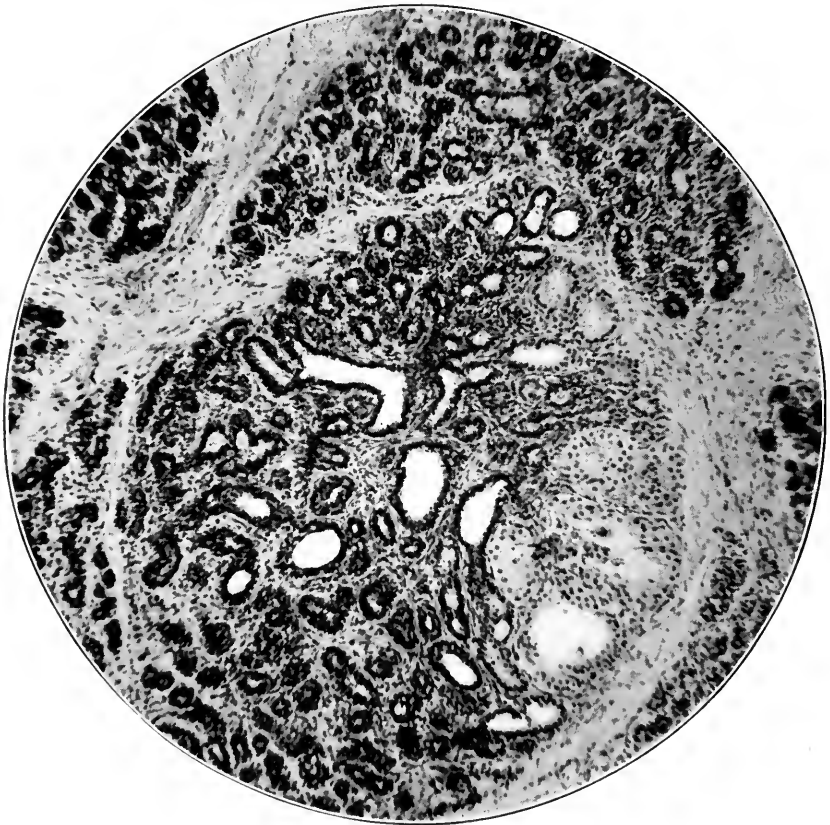


Fig. 53 (Path. No. 11407. BB-13-7 [T-CC]).—Section of a nonencapsulated cystic adenoma. To the right of the lower lobule, an area of alveolar papillary cystadenoma; the remainder of the lobule, cystic adenoma; other lobule, irregular adenoma and solid small alveolar adenoma. This section was first diagnosed adenocarcinoma. First operation: excision of the tumor. Then microscopic examination and twenty-four hours later, second operation: complete for cancer. Result (1921): Well, ten years later. See page 526.

*Result.*—It is now (1921) eight years since the removal of the zone. The patient is married; there have been two children, and lactation in both breasts was normal.



5. *The Nonencapsulated Adenoma Containing One or More Minute Cysts, or One or More Dilated Ducts, or Both (BB-13-5).*—Clinically, this group does not differ from Group BB-13-4; but when one explores the rather indefinite palpable area, one finds, in addition to an irregular, nonencapsulated area shown in Figures 13 and 14, one or more minute cysts or dilated ducts. If the exploration is made slowly and the cyst exposed without cutting it, it has either a blue dome similar to the

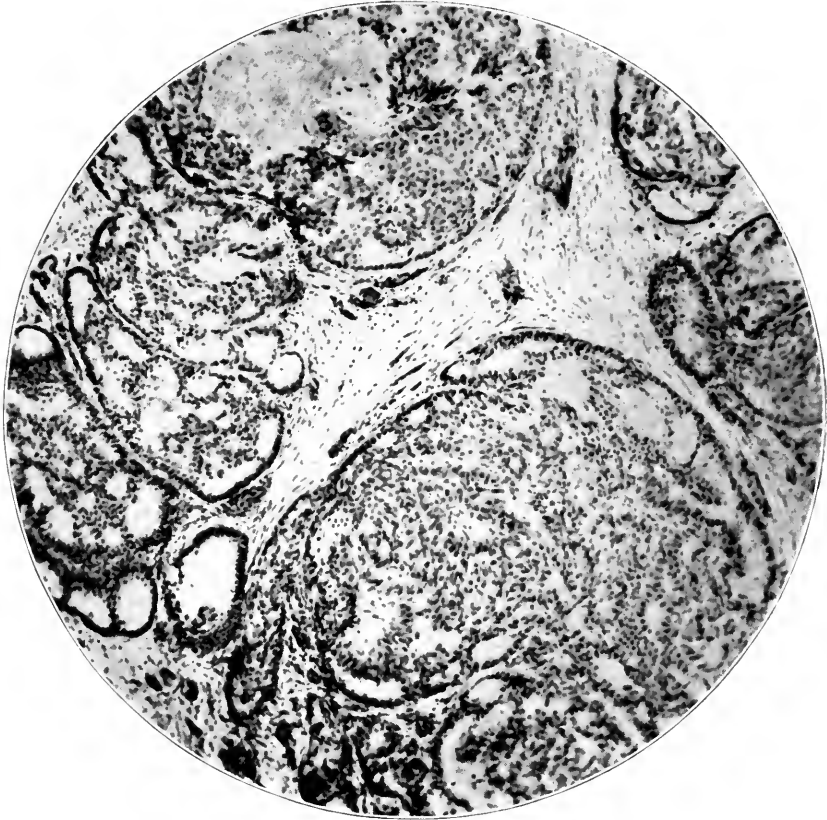


Fig. 54 (Path. No. 3965. BB-13-8 [B]).—Area of papillary cystadenoma from a breast, the seat of diffuse nonencapsulated cystic adenoma. This area was diagnosed in 1901 adenocarcinoma in chronic cystic mastitis. It rested on the pectoral fascia and was removed with but 1 mm. of this tissue, as only the breast was removed. The patient had refused the complete operation. Result (1921): Well, twenty years later. See page 530.

larger blue-domed cysts (Figs. 1, 2 and 4) or an opaque white dome, as shown in Figures 9 and 10, the cyst of the galactocoele type. When the cyst is nicked, the contents are either clear, cloudy or milklike. The moment it is nicked, the contents escape, and one can see the wall of the

cyst. When there is a dilated duct, one does not become aware of its presence until the duct is cut across, and one can distinguish the duct from the cyst by the fact that after some material escapes, more can be expressed like pastil material. With the exception of a duct filled with milklike material, its contents differ from those of a cyst. They are more viscid, as if they contained mucin. They have the consistency of a thin syrup. The color varies: it is usually green or brown; it may be creamlike or milklike. When brown, the contents are often granular and slightly cheesy. Then one can recognize the wall of the duct,

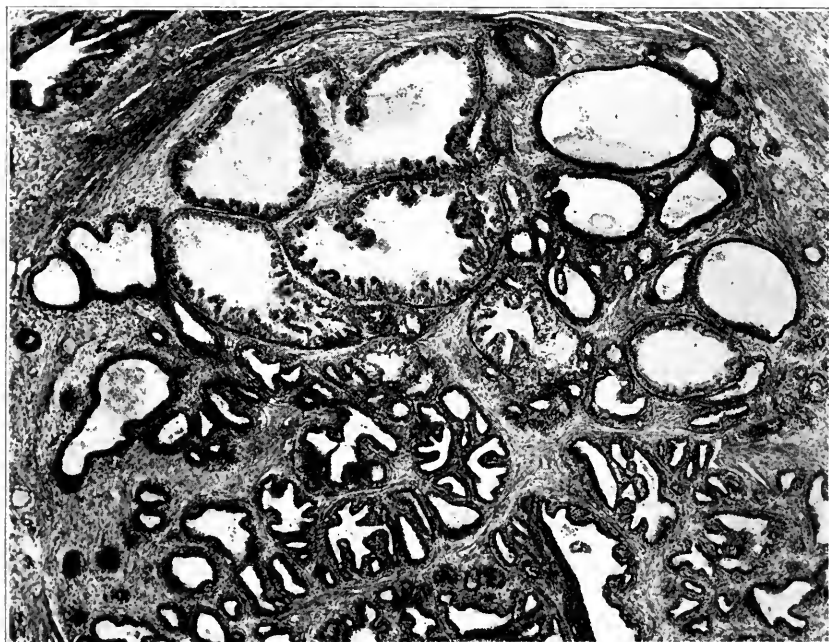


Fig. 55 (Path. No. 21770. BB-12-1 [T]).—Alveolar papillary cystadenoma; cystic adenoma from the wall of a blue-domed cyst (Figs. 7 and 8). This is supposed to be the microscopic picture of diffuse nonencapsulated cystic adenoma, or Schimmelbusch's disease, yet, here it is present as an isolated area in the wall of a blue-domed cyst. Result (1921): Well, four years after excision of the cyst and zone of breast. See page 479.

which is thicker than the wall of the cyst. These dilated ducts with their contents can be easily distinguished from the wormlike masses which are expressed from the comedo-adenoma.

I became familiar with this type first in the examination of breasts which had been completely removed because of a single or multiple palpable tumor. More recently, I have been able to recognize the condition at the exploratory incision, to remove the zone, and save the breast.

Figure 15 (Path. No. 26771. BB-13-5 [T]) shows a section through a zone of breast tissue excised by me, Sept. 23, 1920. It shows both minute cysts and dilated ducts in fibrous and fatty breast tissue and a few adenomatous areas. In the illustration, it is difficult to distinguish the cyst from the duct. Figure 15 should be compared with Figures 13 and 14.



Fig. 56 (Path. No. 26439. BB-13-8 [CC]).—Papillary cystadenoma in ducts. Section of breast, the seat of diffuse nonencapsulated cystic adenoma. For gross appearance, see Figure 26; also see page 537.

*Operation.*—On dividing the palpable area I exposed two minute blue-domed cysts and divided three dilated ducts filled with yellow, cheesy material. The surrounding breast was chiefly fibrous and fatty. A zone of breast only was excised.

*Clinical Note.*—The patient was a white woman, aged 50, still menstruating. Two months before operation she noticed pain in the outer half of the right breast and thought she felt a lump. Both disappeared in a few days. At the next menstrual period, one month before observation, she had less discomfort and felt the lump less distinctly. At my examination, I could palpate an indefinite

area in the midzone of the outer hemisphere, corresponding to the area of pain and where the patient had felt the lump. In the remainder of the right breast and in the left breast, I was unable to palpate any other definite or indefinite lump. The palpable lump was no larger than a twenty-five-cent piece. It did not feel like a cyst, nor did it have the hardness of cancer.

*Microscopic Pathology.*—Usually when there are dilated ducts, we find in the breast surrounding them marked mastitis. This was present in this section (Figs. 67 and 68).

*Result.*—April, 1921, seven months after operation, the patient was well.

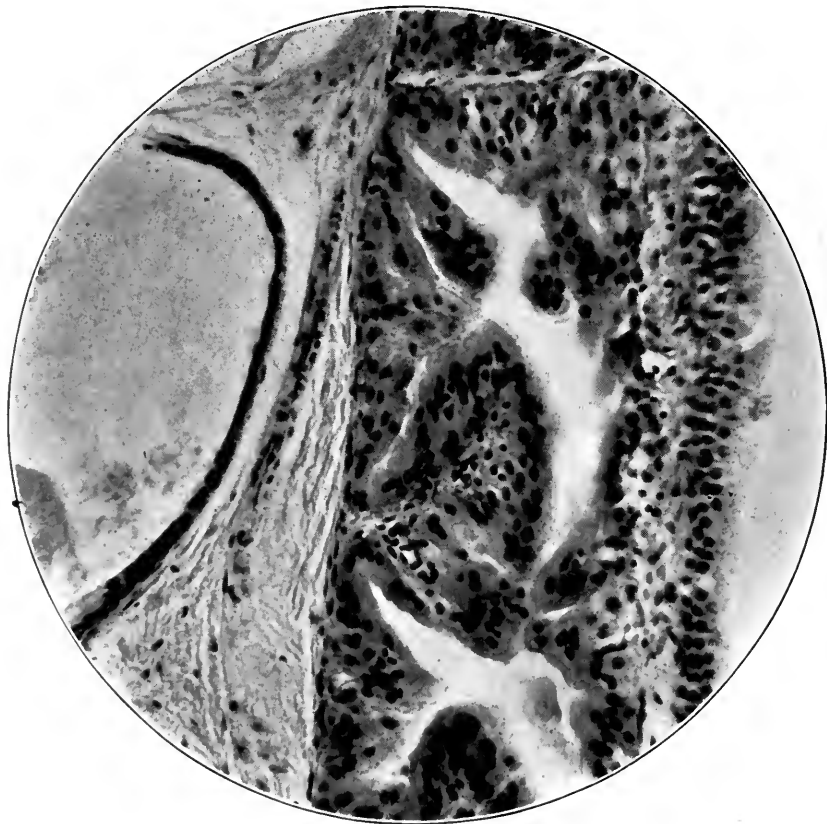


Fig. 57 (Path. No. 20457. BB-13-8 [CC]).—Papillary cystadenoma in duct; epithelium-lined cyst to the left. Section from breast, the seat of diffuse non-encapsulated cystic adenoma (right breast). Excision of breast. Complete operation for cancer on the left breast, two years and eight months later, for diffuse comedo-duct adenoma; no metastasis to the axillary glands. Result (1921): Well, five years after second operation. See page 536.

6. *Diffuse Dilatation of the Ducts, Usually Situated Beneath the Nipple, Rarely Outside the Nipple Zone (BB-13-6).*—For many years, I have been familiar with the dilatation of the ducts filled with different

types of material in breasts which had been completely removed for benign or malignant tumors. The tumors were outside the nipple zone, and the dilated ducts had given no evidence of their presence, either by the palpation of a lump in the nipple zone, or by discharge from the nipple. I had always looked on this condition as a feature of chronic cystic mastitis. In about 1897, I assisted Dr. Halsted in exploring an indefinite palpable lump beneath the nipple. I recollect this lump as feeling like a bunch of worms, and my original notes confirm this

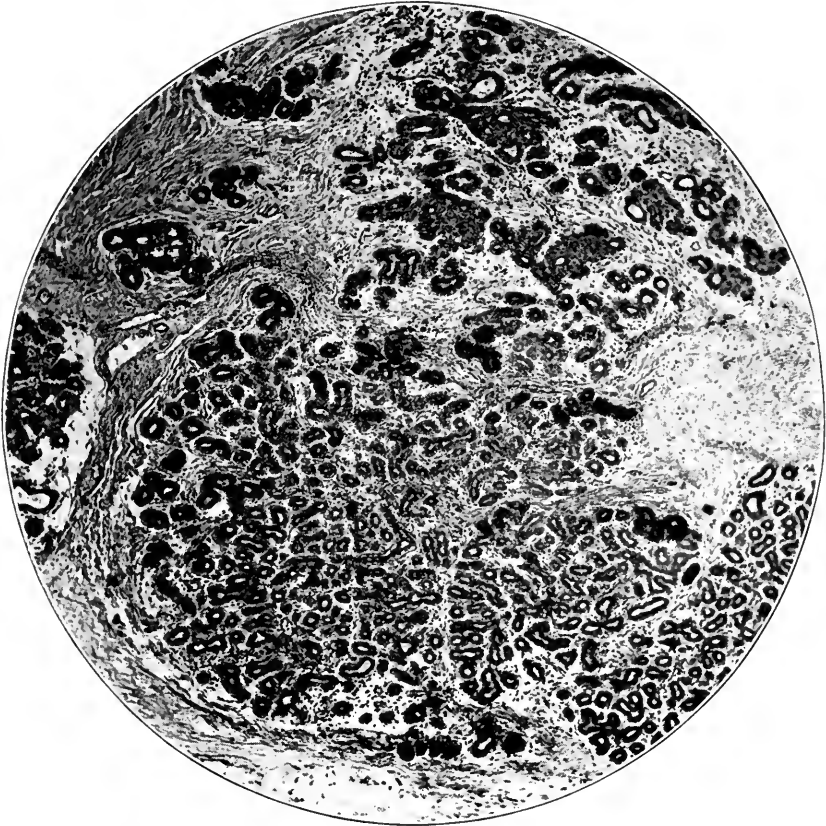


Fig. 58 (Path. No. 22778. BB-13-7 [T]).—Solid small alveolar adenoma. Section from a nonencapsulated cystic adenoma. Small nodule excised in 1915; complete operation for cancer, in 1918, for a second nodule of the same type. No metastasis to the axillary glands. Result (1921): Well, three years after second operation. See page 525.

statement. The indefinite palpable tumor proved to be a dilated duct, with a thick wall about the size of a slate pencil (5 mm.), tortuous and filled with a brown, granular mass. Within a few millimeters of this duct was a minute cyst. At that time we did not look on the condition

found at the exploratory incision as malignant, but concluded that it was safer to perform the complete operation for cancer.

On the gross study of this breast, nothing else was found. The remaining breast tissue was fatty with some fibrous stroma. The sections showed no areas which, even at that time, could be interpreted as suspicious of malignancy, and the sections of the glands showed no metastasis.

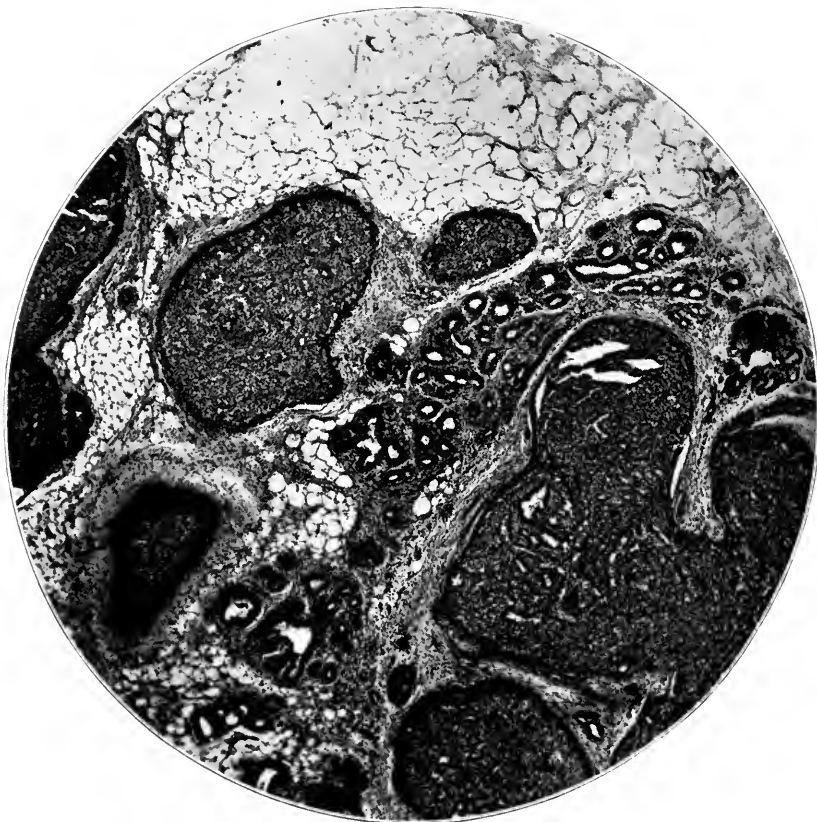


Fig. 59 (Path. No. 26650. BB-12-1 [T]).—Large alveolar duct adenoma. Section from the wall of a blue-domed cyst. This picture is frequently called adenocarcinoma. Result (1921): Well, one year after excision of tumor and zone of breast. See page 525.

This was the first case to be placed in this group. Since then, I have recognized this wormlike tumor beneath the nipple in one or both breasts, and, not feeling justified in being conservative, I have removed one or both breasts. Specimens with the identical gross and microscopic pathology have been sent to me by colleagues who had either removed one or both breasts or performed the complete operation for cancer.

Figure 16*a* (Path. No. 19767) illustrates best the character of the contents of the duct when they are granular and can be expressed like a worm. This picture also shows a few ducts from which the contents had been expressed.

Figure 16*b* (Path. No. 19767), from the same breast, shows a very much larger dilated duct, filled with brown, granular, viscid material.



Fig. 60 (Path. No. 1734. BB-13-7 [B-CC]).—Large alveolar duct adenoma. Section from a small nonencapsulated cystic adenoma. Breast explored by Dr. Halsted in 1897 and removed. The small tumor was considered benign. After microscopic study, it was diagnosed adenocarcinoma, and the complete operation for cancer was performed one month after the first operation. The glands showed no metastasis. Result: The patient was followed for sixteen years, and remained well. See page 521.

In the case illustrated in Figures 16*a* and 16*b*, one breast was removed by me in 1916, and at the present writing (1921), five years later, there is no trouble in the remaining breast.



Figure 17 (Path. No. 24650. BB-13-6 [T]) shows a section through a zone of breast beneath the nipple, which I removed in June, 1919. It shows a large dilated duct filled with brown granular material; it is practically identical with Figure 16. In the white fibrous breast to the right, unopened, dilated, tortuous ducts can be seen, and to the right, at the margin of the specimen, a collapsed, empty dilated duct is observed.

*Clinical Note.*—This patient was a white woman, aged 40. There had been six normal lactations. The last ceased seven months ago, and for some months,



Fig. 61 (Path. No. 13204. BB-13-8 [Expl. CC]).—Small irregular stellate solid adenoma, mixed with cystic adenoma. Section from a breast the seat of diffuse nonencapsulated cystic adenoma. Exploration, gross diagnosis cancer; complete operation for cancer; the glands showed no metastasis. Result (1921): Well, nine years later. See page 536.

she had been conscious of a lump beneath the right nipple. At first, milk could be expressed from the right nipple and then a brownish material.

*Examination.*—Beneath the right nipple a number of wormlike masses could be palpated. There was no induration. Slightly brownish and milklike material could be expressed from the right nipple. The remainder of this breast was



normal. Beneath the nipple of the left breast, the same condition was present to a very slight degree; but nothing could be expressed through the nipple.

*Clinical Diagnosis.*—Naturally one thought of galactocele, but I have no record of a true galactocele with a palpable tumor of this character. This patient was observed about seven weeks. The wormlike tumor beneath the right nipple became more distinct, and the material could be expressed from the nipple, although there was no discharge in the interval. The condition of the left breast remained unchanged.

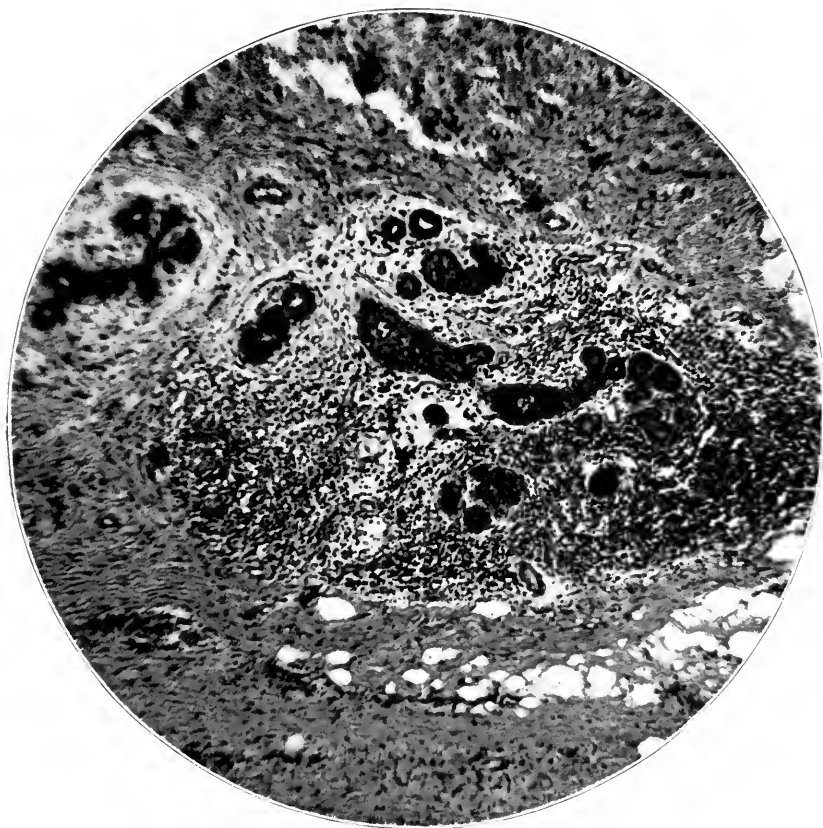


Fig. 62 (Path. No. 8717. BB-12-3 [B]).—Chronic mastitis, alveolar, with atrophy and solid adenoma. Section from the wall of a blue-domed cyst. The breast, the seat of multiple cystic disease, was removed after exploration. Result (1921): Well, thirteen years later. The tumors in the other breast have disappeared.

*Operation.*—The examination on the operating table revealed a tortuous, wormlike, soft tumor, from perhaps 5 to 8 mm. in size, surrounded by smaller wormlike tumors. There was no induration, no fixation or retraction of the nipple, and nothing could be expressed from the nipple. At the exploratory incision, the larger wormlike tumor had a distinct brown capsule and not a blue

dome. On incision its wall was found to be about 3 mm. thick, and it contained thick brownish material (Figs. 16 and 17). Surrounding this larger dilated duct were other smaller ducts, some of which contained milklike, others brown material. In excising this zone and saving the nipple, the surrounding breast tissue was found to be fibrous and fatty.

It was then nine months since lactation had ceased.

*Microscopic Pathology.*—The sections show dilated ducts surrounded by lymphoid granulation tissue and a few adenomatous areas with mastitis; but no lactating breast tissue.

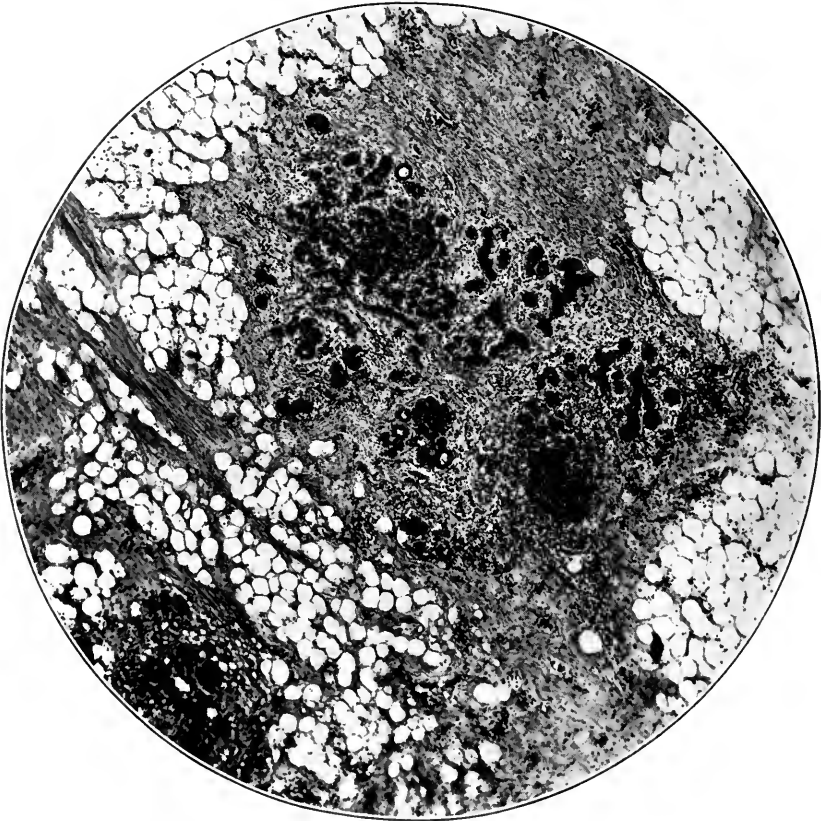


Fig. 63 (Path. No. 26771. BB-13-5 [T]).—Chronic mastitis, alveolar, with solid adenoma and atrophy; also diffuse interstitial. Section from a small nonencapsulated area of breast tissue containing a few dilated ducts and minute cysts. Result (1921): Well, one year after excision of tumor and zone of breast.

*Result.*—At examination in October, 1919, three and one-half months after operation, the right breast appeared normal. The operation had not interfered with the appearance of the nipple. In spite of the excision of the zone beneath the nipple, there was very little induration. Since operation, she had noticed a

slight brownish discharge from the left nipple, and on examination I found that the slight dilatation of the ducts noted at my first examination had increased.

April, 1921, one year and ten months after operation, her physician, Dr. Ries of Baltimore, reported that the patient was well.

*Comment.*—This is the first time that I excised only a zone of breast tissue in a condition of this kind. The observation also demonstrates that the left breast, apparently similar to the affected, has done just as well as the right breast operated on. The object of my operation in this case was to exclude carcinoma.



Fig. 64 (Path. No. 1734. BB-13-7 [B-CC]).—Periductal mastitis in upper half of section; cystic adenoma in lower. Section from a nonencapsulated cystic adenoma. See also Figure 60 from the same case, and page 521.

Figure 18 (Path. No. 27114. BB-13-6) shows a section through a zone of breast excised beneath the nipple. In the upper portion of the upper illustration, there is seen the larger duct filled with a brown material, similar to Figures 16 and 17. In the remaining portion of this section and in the lower picture can be seen the smaller dilated ducts

with thick walls. Some of the ducts are empty, some are filled. The surrounding tissue is fatty, with some fibrous breast stroma. There are no cysts and no adenomatous areas.

*Microscopic Pathology.*—This is similar to that in Path. No. 24650.

*Clinical Note.*—This patient was a white woman, aged 46. The menses were normal. There had been six normal lactations; the last ceased about four years ago. The patient had observed for about two months a yellowish discharge

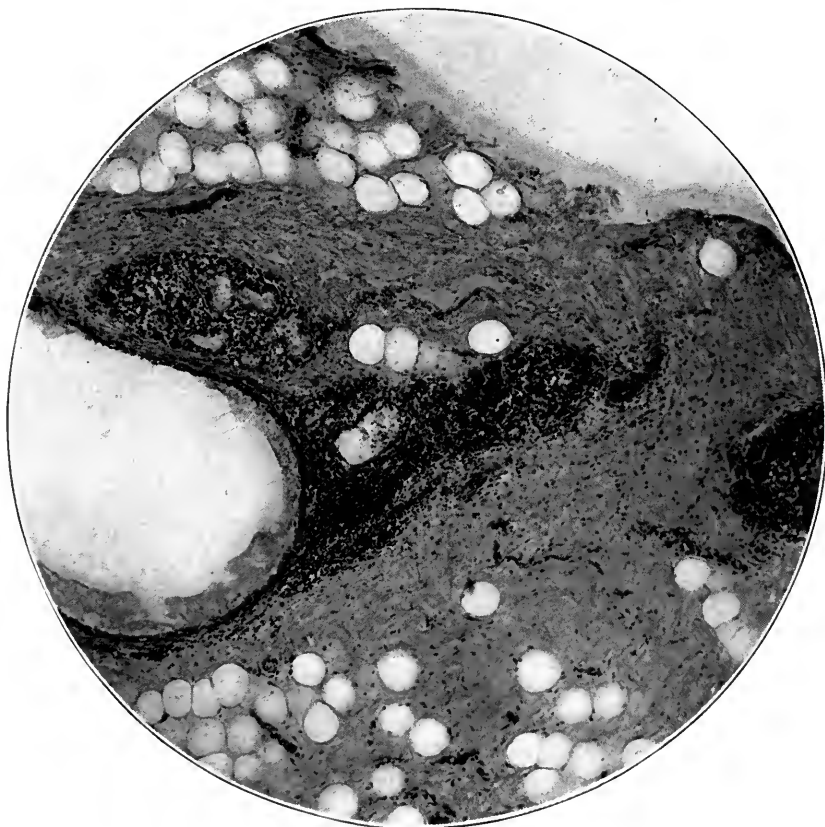


Fig. 65 (Path. No. 19924. BB-13-6 [BB]).—Dilated duct, periductal mastitis; alveolar mastitis with atrophy. From section of breast tissue filled with dilated ducts beneath the nipple. For gross appearance, see Figure 18.

from the left nipple, which had produced a slight eczema and had been diagnosed Paget's disease. There had now been no discharge for one month, and all the signs of irritation had disappeared. The patient had not felt a tumor.

*Examination.*—Both breasts were very large and had been so since puberty. Beneath the left nipple, there were a number of wormlike, soft masses, and this nipple might be slightly pulled in, but there was no fixation. About the wormlike masses, there was no induration. The remainder of this and the other breast were normal.

*Operation.*—Nov. 19, 1920, on dividing the fat, numerous dilated, wormlike masses were exposed. Their capsules were brown; some were as large as a slate pencil (5 mm.). On incision, they contained brown, granular material. In cutting out the zone beneath the nipple, other, smaller dilated ducts containing the same material were cut through, and when pressed upon gave the appearance illustrated in Figure 16.

*Result.*—In 1921, six months since operation, I am informed that the patient is well.

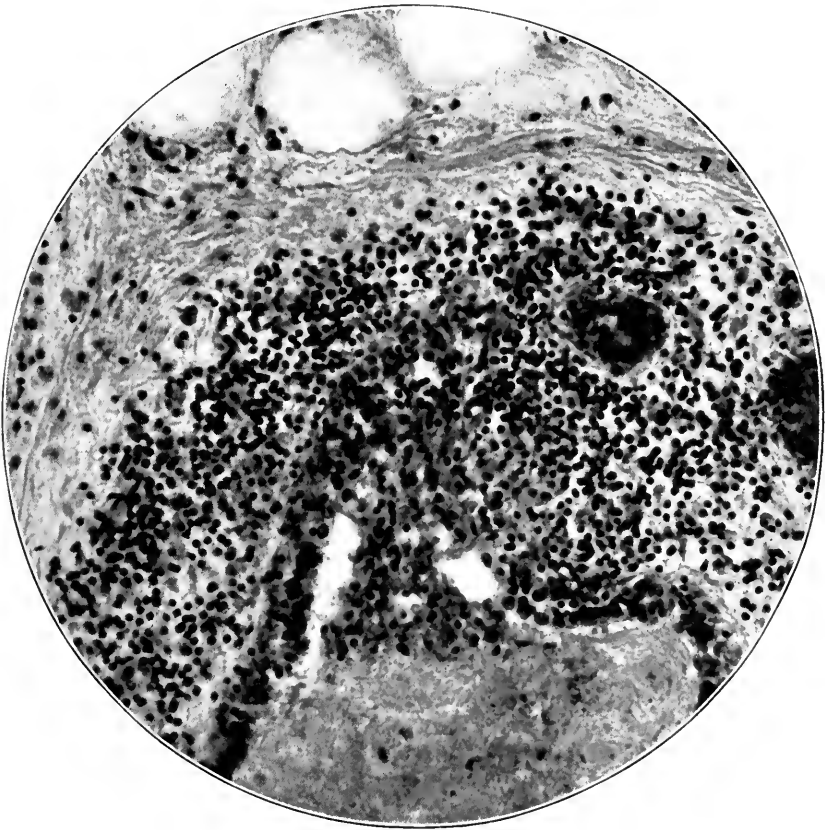


Fig. 66 (Path. No. 19994, BB-13-6 [BB]).—High power magnification of area shown in Figure 65. Dilated duct; periductal mastitis; duct filled with proliferating, degenerating cells; basement membrane destroyed; basal-cell arrangement abnormal, due to inflammatory, not neoplastic, process.

After the operation I took the history again, because the patient had been very nervous before operation. I then found that the slight retraction of the nipple had been observed just before she ceased nursing her youngest child, two and one-half years ago. A clinical finding of this kind excludes retraction of the nipple as a sign of cancer. She had had pain beneath the nipple in the affected breast one year, and then, four or five weeks ago, had noticed the yellow

discharge, following which there was some excoriation of the nipple. In this stage she had been examined in three clinics, with a diagnosis of Paget's disease of the nipple.

Figures 20*a* and 20*b* (Path. No. 27935. BB-12 [6-CC]). Figure 20*a* shows a section through the zone of breast beneath the nipple which illustrates the dilatation of the ducts with their thick walls. Figure 20*b* is a lymph gland from the axilla which is enlarged, due to chronic

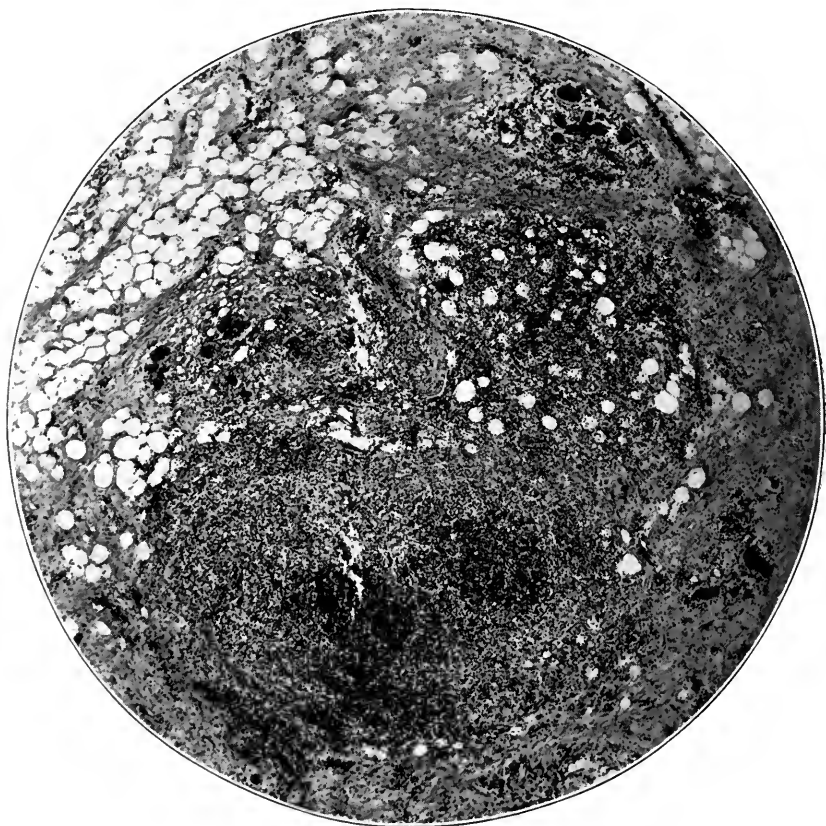


Fig. 67 (Path. No. 26771. BB-13-5 [T]).—Alveolar mastitis with atrophy; diffuse interstitial mastitis with zones of granulation tissue. The apparent giant cells are remains of ducts or alveoli. See Figure 68, from same case, and page 500.

lymphadenitis and shows no metastasis. This specimen was sent to me by my former resident surgeon at St. Agnes Hospital, Dr. Loos of Bay City, Texas.

The patient was a white woman, aged 51, with eight children, the youngest, aged 7 years. The menopause had occurred three years before. The onset of the trouble in the breast was sudden, of three weeks' duration. There were pain and swelling of the breast like mastitis; this disappeared at the end of one

week and then recurred. On palpation, a mass was found in the nipple zone the size of a silver dollar. The skin over this area was red. The mass gave the sensation of fluctuation, with a zone of indurated breast about the fluctuating area. There had been a discharge of pus from the nipple for three days, and the nipple was slightly retracted.

On account of this clinical picture, Dr. Loos performed the complete operation for cancer; but on gross study after operation, he concluded that it was benign and due to infection of the dilated ducts beneath the nipple.

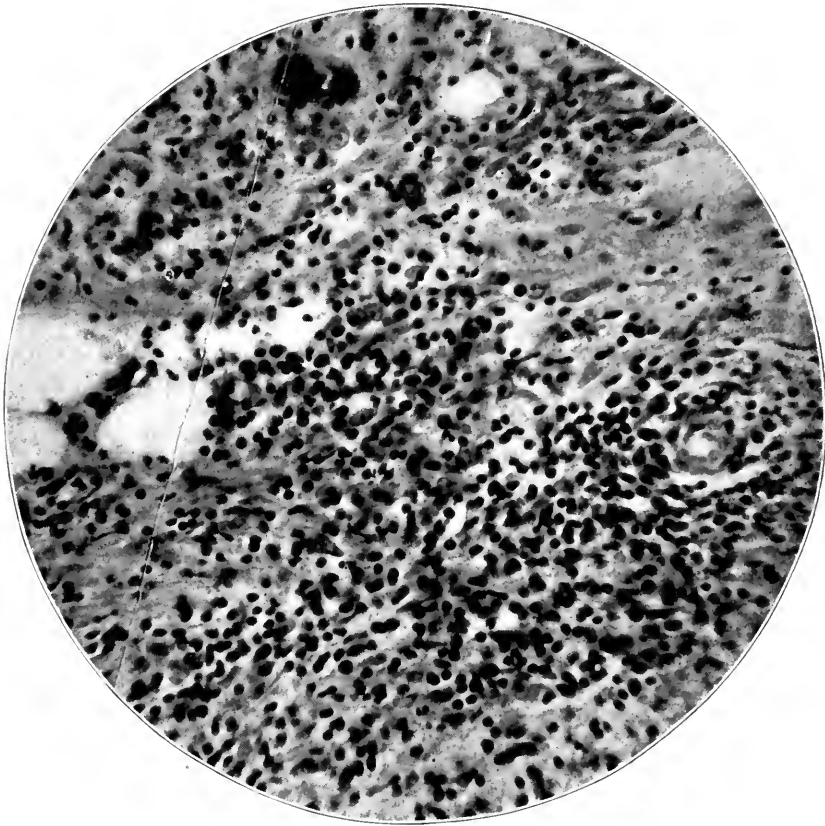


Fig. 68 (Path. No. 26771. BB-13-5 [T]).—High power magnification of area shown in Figure 67. See page 500.

In my experience, cancer never begins as acute mastitis and never gives the clinical picture of an abscess. In this group of BB-13-6 (twenty-two cases), there have been at least three cases with this clinical picture of an abscess due to infection of a dilated duct.

*Clinical Note.*—In another case (Path. No. 21192. BB-13-6 [B], Figures 19 and 78), the diffuse dilatation of the ducts involved a zone outside the nipple. The onset was similar to that in Path. No. 27935. There were pain and swelling of the right breast, resembling mastitis, of ten days' duration, in a



white woman, aged 51. The menopause had occurred some years previously. The youngest child was 17. The outer hemisphere of the right breast was so hard and swollen that Dr. Hahn, her physician, applied ice. The acute symptoms subsided.

At my examination, ten days after the onset, the skin and nipple were normal. There was a mass in the outer hemisphere of the right breast which felt like "caked" breast in lactation mastitis. However, the edge of the involved hemisphere was not palpable as in BB-13-8, the diffuse nonencapsulated cystic



Fig. 69 (Path. No. 20718. BB-13-4 [B]).—Section from small organized hematoma in a small nonencapsulated adenoma. Breast removed without exploratory incision. Result (1921): Well, five years later.

adenoma, nor were there shotlike nodules to be felt. The condition was undoubtedly subsiding.

At the operation, in March, 1917, I felt it safer to excise the entire breast. The gross appearance is shown in Figure 19. The involved zone of breast is nonencapsulated and distinct from the remainder of the breast, which is fatty and senile. There are no dilated ducts beneath the nipple. The surface of the involved area is covered with milklike, grumous, gray, pastil material, shown in the illustration, which, when wiped away, exposed dilated ducts with thick



walls. The microscopic picture is shown in Figure 78. The ducts were filled with degenerating, desquamating cells, and surrounded by periductal mastitis.

*Result.*—Four years after operation (1921), the patient was well.

THE NONENCAPSULATED CYSTIC ADENOMA, BB-13-7, EIGHTEEN CASES

The original diagnosis in this case (Path. No. 1210. BB-13-7 [CC], Figures 22 and 77), made in 1896, was adenocarcinoma in

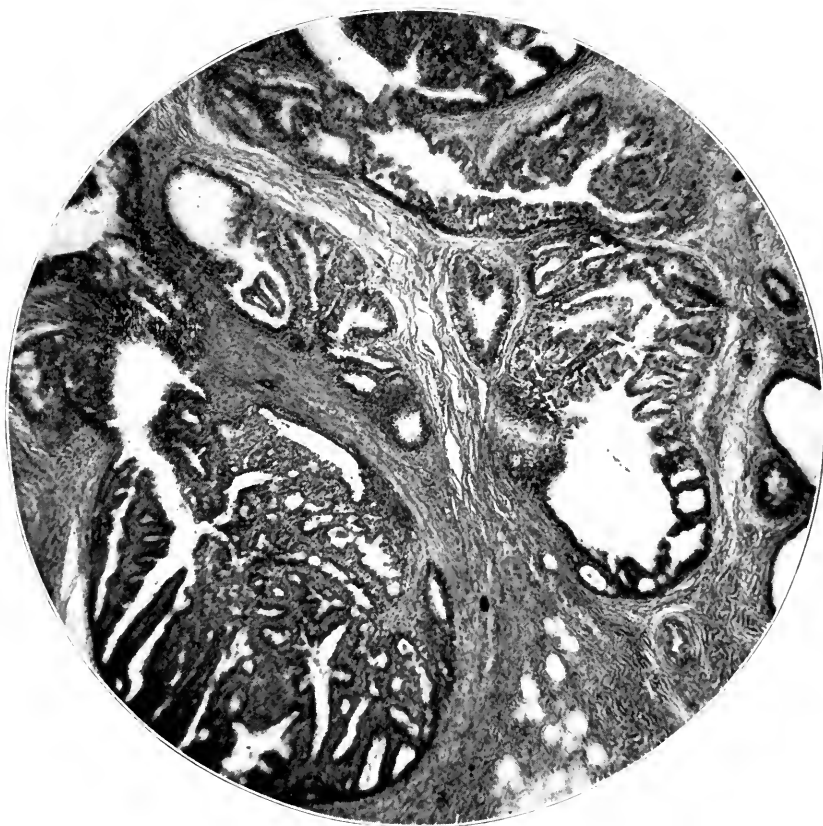


Fig. 70 (Path. No. 12826. BB-13-7 [B-CC]).—Area of papillary cystadenoma. In places, basal-cell arrangement abnormal; basement membrane apparently destroyed. See Figure 71, section from a nonencapsulated cystic adenoma. The operator first removed the breast without exploration; the section was diagnosed adenocarcinoma and the complete operation for cancer performed forty-eight hours later. The glands showed no metastasis. Result (1921): Well, nine years later. See page 525.

nonencapsulated cystic adenoma. But my original note does not describe carcinoma, and restudy of the section discloses no areas of cancer, as shown in Figures 87 and 88.

My original description is as follows: "The tumor (Fig. 22) is the size of a 25-cent piece, not encapsulated; chiefly circumscribed; in places infiltrating; definite fibrous trabeculae surrounding cellular alveoli; no comedones, dilated ducts or cysts." My conclusions, then, from the gross specimen were that the diagnosis rested between medullary cancer and solid intracystic papilloma. The remainder of the breast about

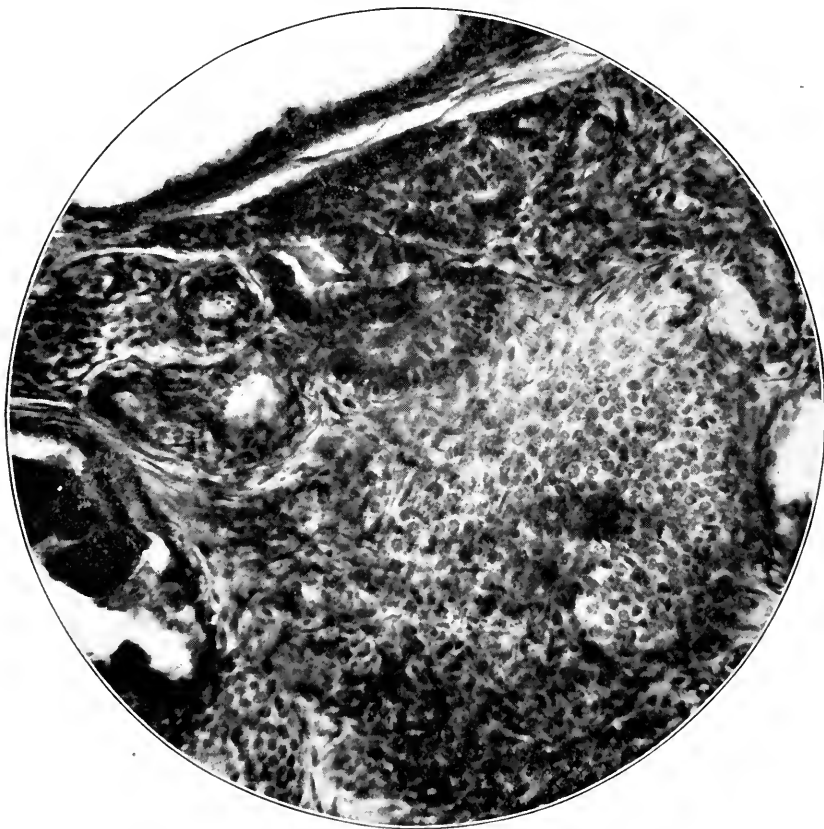


Fig. 71 (Path. No. 12826. BB-13-7 [B-CC]).—High power magnification of area shown in Figure 70, to illustrate the destroyed basement membrane and the abnormal arrangement of the basal cells in some areas.

this nonencapsulated tumor is not described. From what we have now left of the breast in the laboratory, it was a senile fatty breast.

The predominant microscopic picture is shown in Figure 77, papillary cystadenoma. Other portions of the tumor show cystic adenoma, epithelium-lined cysts, irregular adenomatous areas with mastitis. The axillary glands showed no metastasis.

Clinical Note.—This tumor was of ten years' duration in a woman, aged 62. It began just before the menopause, nineteen years after the last lactation. During the last year there had been pain, slight growth, and retraction of the nipple. The tumor felt like a mulberry—hard and lobular—and not like cancer. On account of the retraction of the nipple and the slight atrophy of the subcutaneous fat, Dr. Halsted performed the complete operation for cancer. This patient lived to the age of 75 and died of apoplexy, more than thirteen years after operation.

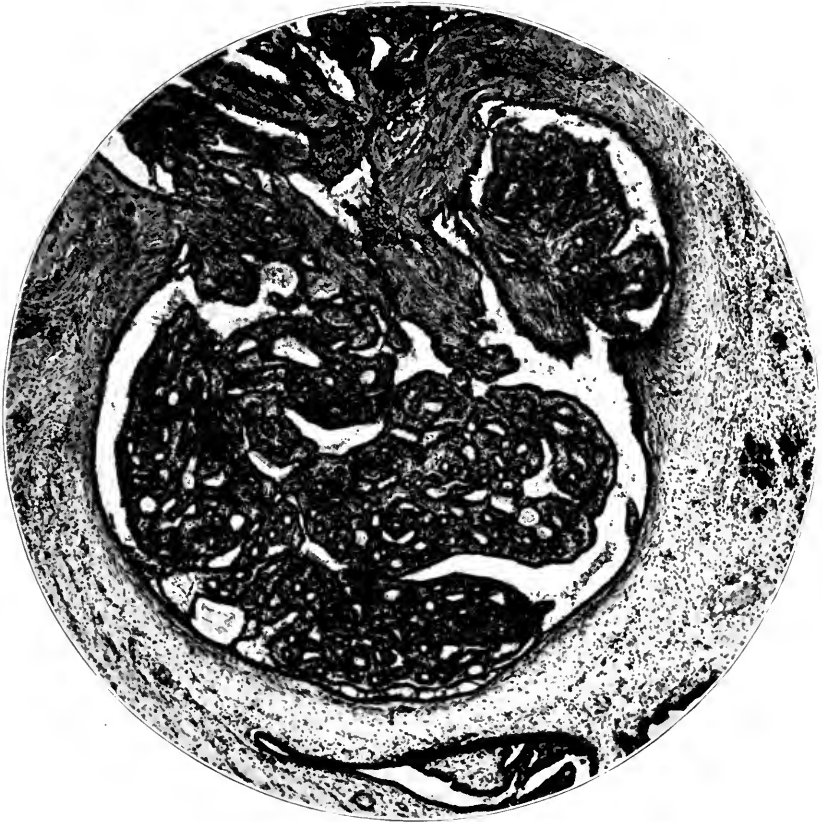


Fig. 72 (Path. No. 28138. BB-13-7 [T-CC]).—Papillary cystadenoma; basement membrane intact; arrangement of basal cells, normal. Section from a nonencapsulated cystic adenoma. The surgeon explored; the pathologist diagnosed adenocarcinoma; immediate complete operation for cancer was performed. The glands showed no metastasis. Recent case. In 1913, eight years previously, I had removed from this breast a small nonencapsulated adenoma (see Fig. 32). In the interval, there have been two normal lactations. In my opinion, the second operation, complete for cancer, was unnecessary.

I explored the tumor (Path. No. 17012. BB-13-7 [Ex CC], Figs. 21, 90 and 91) shown in Figure 21, in 1915. As it looked and felt like cancer I immediately performed the complete operation. The

glands in the axilla showed no metastasis. The patient is well in 1921, six years after operation.

*Clinical Note.*—My clinical impression in this case was that I was dealing with a benign tumor because of its long duration—twenty-two years, probably an old adenoma because the patient now aged 42, had felt the tumor at the age of 10. The tumor had not changed during two lactations, the last ten years ago. She came for operation, not because of any change in the tumor, but for the reason that she had read that lumps in the breast should be removed. This tumor, not larger than a ten-cent piece, was in the periphery of the upper and outer quadrant of the right breast, and felt spherical, like a cyst.

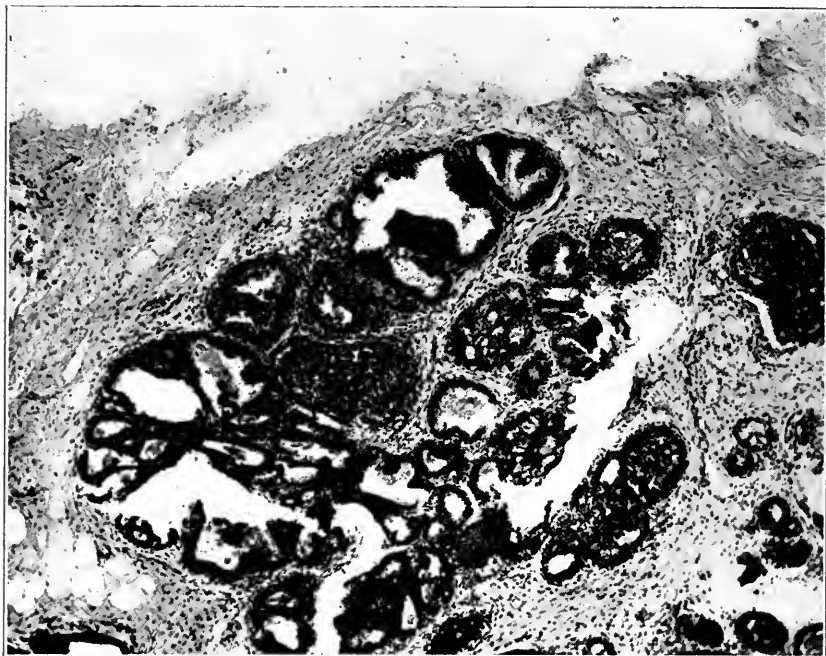


Fig. 73 (Path. No. 14539. BB-12-1 [T]).—Area of papillary cystadenoma and large alveolar duct adenoma; in places, basement membrane destroyed and basal-cell arrangement abnormal. Section from the wall of a blue-domed cyst. Excision of cyst only in 1910. Result (1921): Well, eleven years later. Histologically, this section is more suspicious of malignancy than any other picture among these illustrations. Yet, cancer has not developed since the excision of the cyst.

When exploring, I cut through white, firm breast tissue. The tumor had no capsule. On section (Fig. 21), it appeared circumscribed, opaque-white, with fine, granular dots and lines. It had the hardness of cancer and the surface appearance of cancer; yet, nothing could be expressed from its surface. It never occurred to me that it was not cancer. But, when I studied the sections (Figs. 90 and 91), I found I was dealing with a nonencapsulated cystic adenoma, partly of the solid, small and large adenomatous type; some cystic adenoma (Fig. 90) and some areas of papillary cystadenoma (Fig. 91), resembling somewhat lactation adenoma (Fig. 33).

*The Gross Appearance of Nonencapsulated Cystic Adenoma.*—Unfortunately among the eighteen cases, these are the only two which we were able to photograph. Of the eighteen cases, eleven have been received from outside sources, seven from the Johns Hopkins Surgical Clinic and one from my own service at St. Agnes Hospital. Of six patients operated on at Johns Hopkins, I either assisted Dr. Halsted at the operation in the early years, or saw the tumor in the laboratory.



Fig. 74 (Path. No. 12451. BB-13-7 [B-CC]).—Papillary cystadenoma; basement membrane destroyed; basal-cell arrangement abnormal. For high power magnification, see Figure 75. Section from an area of nonencapsulated cystic adenoma. The operator considered it benign and removed the breast. The pathologist diagnosed it adenocarcinoma. The complete operation for cancer was performed one month later; the glands showed no metastasis. Result (1921): Well, nine years later. One normal lactation in remaining breast since operation. See page 525.

It seems important to give a detailed description of these cases examined by me, because they represent the type of chronic cystic mastitis most difficult to distinguish from cancer.

Path. No. 468, operation by Dr. Halsted in 1894. The tumor in the upper and outer quadrant was the size of a silver dollar, circumscribed, but not encapsulated. On section, it appeared largely composed of minute cysts containing gelatinous material. Between the cysts, there were white granular alveoli separated by fibrous trabeculae. That is, it resembled Figure 22, except that the tumor contained cysts. In the center of this tumor, there was a calcified area. I might note here that I have never seen calcification in cancer, only in old fibro-adenomas. The microscopic section showed cystic adenoma, fibro-adenoma, a few areas of papillary cystadenoma, calcification and mastitis. The original diagnosis was adenocarcinoma in old adenofibroma. The glands showed no metastasis. This patient lived nineteen years and died of old age, at 74.

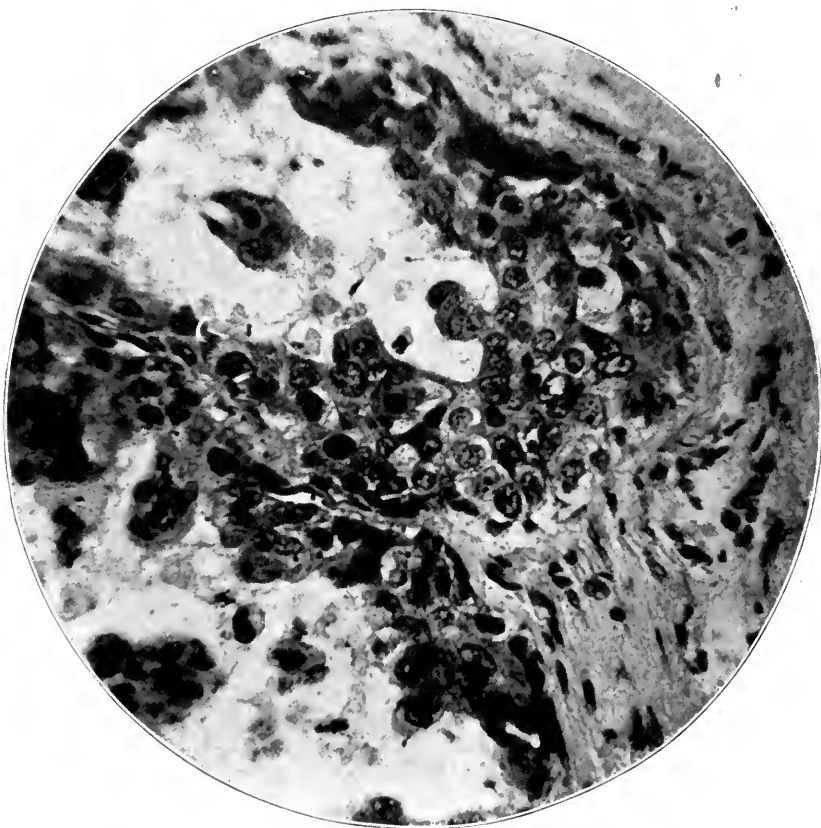


Fig. 75 (Path. No. 12451. BB-13-7 [B-CC]).—High power magnification of area shown in Figure 74. See page 525.

This patient presented the clinical picture of a benign lesion. In the first place, there were multiple tumors of both breasts of thirty-five years' duration in a woman, aged 55. These tumors had remained unchanged during lactation. The multiple tumors in the left breast were distinctly benign, and some gave the sensation of crepitation, due to calcification. One of the multiple tumors in the right breast in the upper and outer quadrant had shown growth during the

last six months, and the skin over it had become bluish. This tumor was diagnosed clinically cancer, and the complete operation performed without exploration. One of the multiple tumors of the left breast was excised and showed calcification.

Here we have the evidence that a benign tumor, one of multiple tumors, may grow after years of quiescence and give the clinical picture of a malignant tumor. Up to the present time, we have never seen cancer develop in one of multiple fibroadenomas. Billroth in his book pictures such an instance.



Fig. 76 (Path. No. 5221, BB-13-8 [CC]).—Papillary cystadenoma; in places basement membrane destroyed; arrangement of basal cells abnormal. Section from a breast, the seat of diffuse nonencapsulated cystic adenoma. For gross appearance, see Figure 25. The original diagnosis in this case was adenocarcinoma in Schimmelbusch's disease. See page 531.

Path. No. 1147. I assisted Dr. Halsted in exploring this tumor in 1895. It presented a small area of induration near the nipple. My original description records an infiltrating tumor about a nonencapsulated cystic adenoma, the size of a ten-cent piece. The center of the tumor contained a few cysts, gray-granular



alveoli in fibrous trabeculae from which semifluid material could be expressed. The infiltrating area about this resembled cancer of the scirrhus type, and sections from this area show scirrhus carcinoma (Figs. 86 and 87). As already noted, this is the only one among the eighteen cases of nonencapsulated cystic adenoma which presented the microscopic picture of cancer.

This patient was well (1921), twenty-six years after the complete operation. The glands in the axilla showed no metastasis.



Fig. 77 (Path. No. 1210. BB-13-7 [CC]).—Area of papillary cystadenoma; basement membrane in places destroyed; basal-cell arrangement abnormal. Section from a nonencapsulated cystic adenoma. For gross appearance and clinical history, see Figure 22; also see page 513.

This is a very important observation, and should make one suspicious of nonencapsulated tumors resembling cystic adenoma. But it is important to note that we recognized the malignancy in the gross at the exploratory incision and confirmed the diagnosis under the microscope.

Path. No. 1210 has been described (Figs. 22 and 77, page 513).



Path. No. 1734. I assisted Dr. Halsted also in exploring this tumor in 1897. The tumor was clinically benign, and at operation, it was looked on as a nonencapsulated cystic adenoma, composed chiefly of minute cysts containing brown-gray material and some milky fluid. At first, only the tumor was removed; then, after microscopic study with the diagnosis of adenocarcinoma, the complete operation was performed, one month later. The glands showed no metastasis. This patient was followed sixteen years until 1913, and there was no evidence of recurrence.

For microscopic pictures, see Figures 60 and 64.

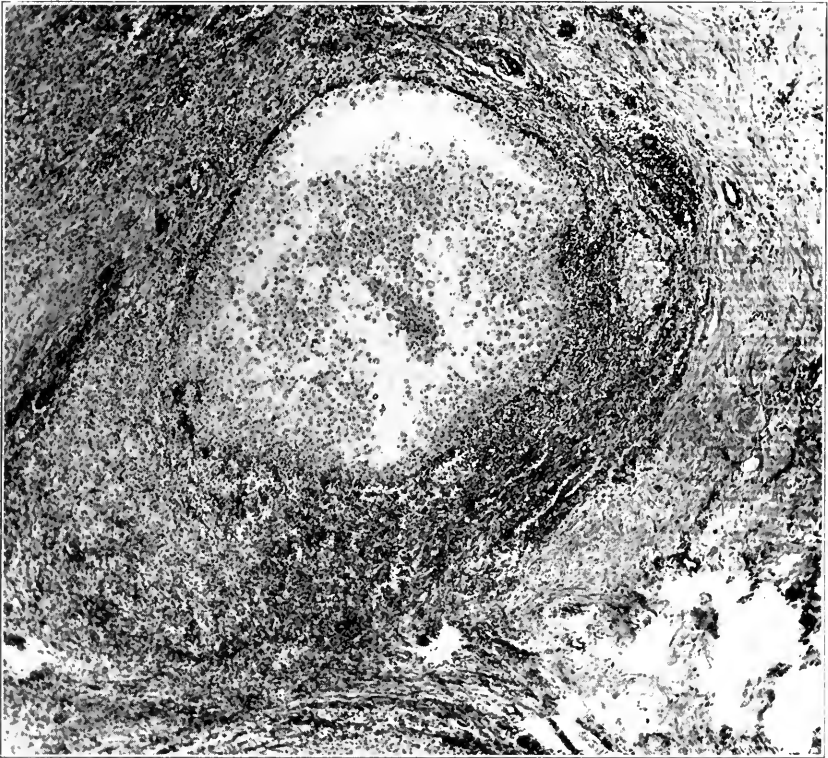


Fig. 78 (Path. No. 21192. BB-13-6 [B]).—Section of dilated duct filled with proliferating and degenerating cells, surrounded by periductal mastitis, from a breast, the seat of diffuse dilatation of ducts outside the nipple area. For gross appearance, see Figure 19, also page 511.

Path. No. 2145. In 1898, Dr. Finney at the Union Protestant Hospital performed the complete operation for cancer without exploratory incision, and sent the specimen to me. My description was as follows: "Palpable tumor in the upper and outer quadrant the size of a twenty-five-cent piece, nodular; clinically benign; on section the tumor was a nonencapsulated area of minute cysts containing brownish fluid surrounded by dense fibrous tissue." My diagnosis then, from the gross and microscopic study, was a benign nonencap-

sulated cystic adenoma. The sections show cystic adenoma, large solid adenoma similar to Figure 60 and irregular stellate adenoma in fibrous tissue (Fig. 80). The glands showed no metastasis, and this patient is well (1921), twenty-three years after operation.

Path. No. 3842. In 1901, Dr. Mitchell, then resident surgeon of Johns Hopkins Hospital, excised a tumor from the right breast of this patient, which I described as follows: "The tumor is the size of a fifty-cent piece and is composed of many minute cysts containing milky fluid." Gross diagnosis: Nonencapsulated cystic adenoma. The microscopic sections showed all the stages

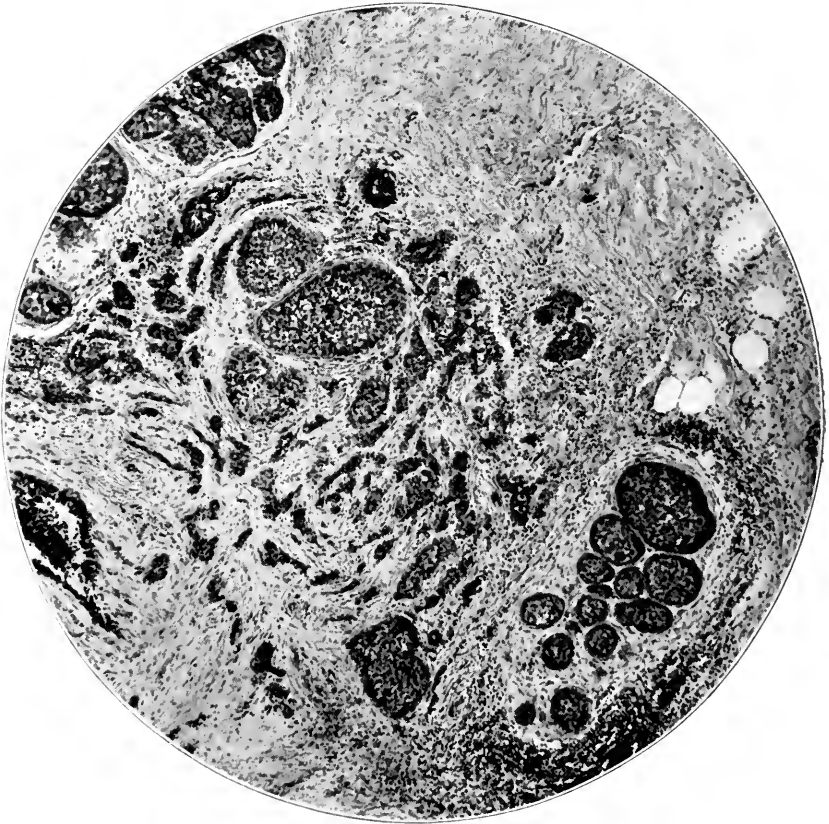


Figure 79 (Path. No. 21371, BB-13-7 [Expl. CC]).—Section of breast showing area of large solid duct adenoma and small irregular stellate adenoma. From a nonencapsulated cystic adenoma, diagnosed doubtful at exploration. Cancer operation; no metastasis to glands. Result (1921): Well, four years later. See page 524.

of chronic cystic mastitis, illustrated in this paper. Therefore, Mitchell was the only surgeon who removed only the tumor in this group of cases. Clinically, there were multiple tumors in both breasts; each breast had one distinct tumor, and, in addition, there were multiple shotlike nodules in both breasts.

Two years later, the patient wrote that another surgeon had removed the other breast. Since this date we have been unable to follow this patient.

In my opinion this is an example of multiple cystic adenoma.

Path. No. 8068. In 1907, Dr. Halsted explored this tumor, diagnosed it colloid cancer, and performed the complete operation. Dr. Porter, in the laboratory, described the gross appearance as follows: "A small, circumscribed, nonencapsulated area with many minute cysts containing drops of fluid with granular alveoli between the minute cysts." His gross diagnosis was non-encapsulated cystic adenoma with a possibility of early cancer. My microscopic description was as follows: "The tumor is chiefly a papillary cystadenoma

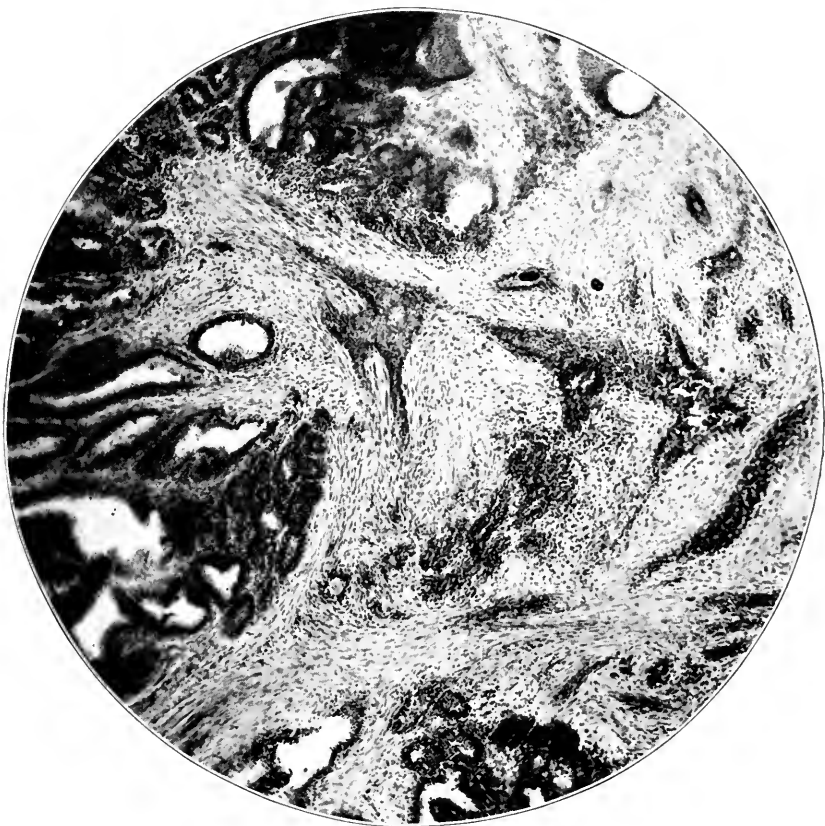


Fig. 80 (Path. No. 2145. BB-13-7 [CC]).—Area of small irregular stellate solid adenoma; basement membrane in places destroyed; basal-cell arrangement abnormal, but cells not of the cancer type. Other lobules show chiefly cystic adenoma. The glands showed no metastasis. Result (1921): Well, twenty-three years after the complete operation for cancer. See page 521.

with small epithelium-lined cysts and many adenomatous areas of different types. Diagnosis: Benign, nonencapsulated cystic adenoma." The glands showed no metastasis. This patient was well (1921), sixteen years later.

Path. No. 17012. This has been discussed (Figs. 21 and 90, page 515). In this case, I diagnosed the tumor as cancer at exploration.

Path. No. 21371. In 1917, Dr. Finney at the Women's Hospital explored this tumor, removed the breast and, after careful gross examination, performed the complete operation for cancer. When I received the specimen, it was much cut up, but I could recognize a nonencapsulated tumor, the size of a twenty-five-cent piece containing a few minute cysts buried in granular white tissue. This tumor, therefore, resembles Figure 21, except that it contained a few cysts. Its gross appearance was very suggestive of malignancy. The most suspicious area of the tumor is shown in Figure 79. The glands showed no metastasis. This patient was well (1921), four years after operation.



Fig. 81 (Path. No. 14094. BB-13-7 [T-CC]).—Area of solid large adenoma; basement membrane in places destroyed; basal-cell arrangement abnormal. For high power magnification, see Figure 82, in which the irregular cells are somewhat of the cancer type. The tumor was a nonencapsulated cystic adenoma. After removal and microscopic examination, the complete operation for cancer was performed in twenty-four hours; there was no metastasis to the glands. Result (1921): Well, eight years later. See page 525.

Therefore, among the eighteen patients with nonencapsulated cystic adenoma, nine, or 50 per cent., have been operated on by Dr. Halsted or his associates in his clinic; only one, or about 10 per cent., has shown

microscopically fully developed cancer. All but one were immediately or ultimately subjected to the complete operation for cancer. Up to the present time, all are well.

Nine cases, therefore, may be considered the proper proportion of this type in one large clinic in thirty years.

During the same period, nine specimens were sent to me for diagnosis, and they came from nine different surgeons in nine different



Fig. 82 (Path. No. 14094. BB-13-7 [T-CC]).—High power magnification of area shown in Figure 81. Area of small, irregular stellate adenoma; basement membrane destroyed; arrangement of basal cells abnormal; cells of the cancer type. See page 525.

states, demonstrating that the lesion is rare, excites interest, and pathologists disagree as to the diagnosis or benignity or malignancy. All of these patients were immediately or ultimately subjected to the complete operation for cancer. In none did the glands show metastasis. All have been followed, and none have had a recurrence or have died of cancer.

Photomicrographs of some of these cases are reproduced herewith (Figs. 53, 58, 59, 70, 74 and 81).

I am confident that it is this group of tumors that has given rise to the impression that it is not dangerous to excise a malignant tumor of the breast, submit it to microscopic study and then perform the complete operation for cancer some days or weeks later.

This type of tumor, when diagnosed adenocarcinoma, increases the percentage of cures of cancer, not only in this group, but the total

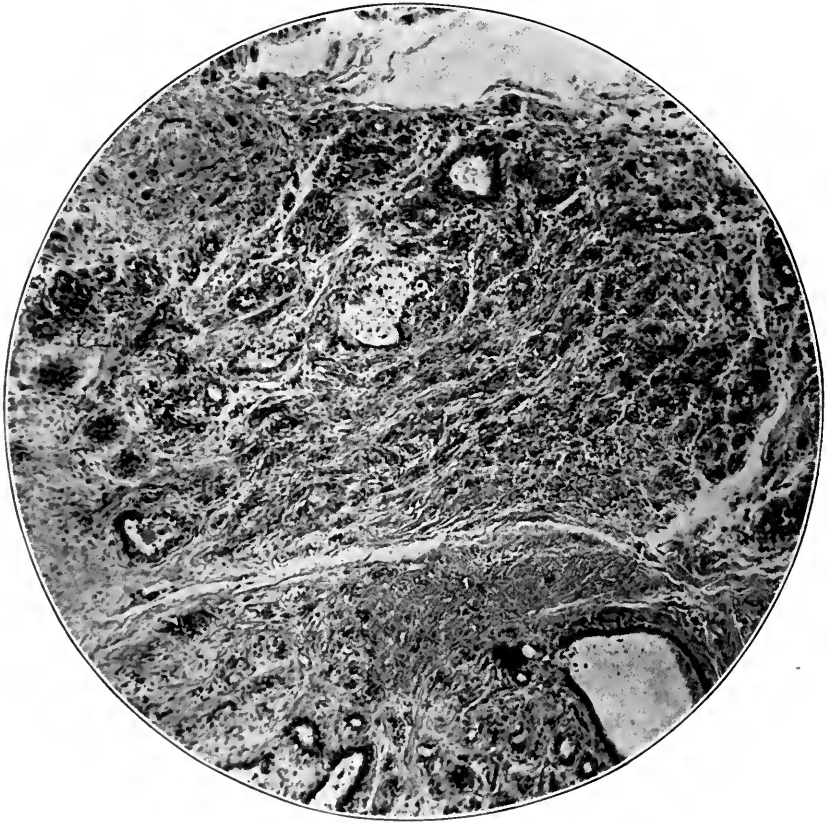


Fig. 83 (Path. No. 3965. BB-13-8 [B]).—Area of small irregular adenoma; basement membrane in places destroyed; basal-cell arrangement abnormal; cells of the basal, or resting, type; not of the cancer type. Section from breast, the seat of diffuse nonencapsulated cystic adenoma. For gross appearance, see Figure 23; for other microscopic area, see Figure 54; also see page 530.

percentage of operative cures of cancer of the breast. When these cases and some of those in group BB-13-8 were included in our cases of cancer of the breast, they increased the percentage of five-year cures. For example, when we considered all cancer of the breast without

metastasis to the glands and included these two groups with the comedo-adenoma, the percentage of five-year cures was more than 80; when we exclude these three groups, the percentage drops to 60.

*Is There Such a Tumor As Adenocarcinoma of the Breast?*—This intensive restudy has almost convinced me that there may be no such thing as adenocarcinoma. The malignant tumor should be called *carcinoma and adenoma*. I have shown here, among eighteen cases of non-encapsulated cystic adenoma, one with microscopic evidence of fully



Fig. 84 (Path. No. 12586. BB-13-8 [CC]).—Area of small solid adenoma; basement membrane in places apparently destroyed; arrangement of basal cells in areas abnormal, but cells of the resting basal type; some areas of cystic adenoma and dilated ducts. For clinical picture, see Figure 29; for high power magnification, see Figure 85; also see page 534.

developed cancer. This case should be diagnosed *scirrhous carcinoma and cystic adenoma*. The remaining seventeen cases belong to the group of benign nonencapsulated cystic adenoma. Yet all these seventeen cases have been diagnosed adenocarcinoma by one or more pathologists.



The same is true of BB-13-8, the diffuse nonencapsulated cystic adenoma. Of the thirteen cases, there is microscopic evidence of cancer in only one (Fig. 88), and this patient is dead of cancer. Yet, in the remaining twelve cases, one or more pathologists have made the diagnosis of adenocarcinoma in Schimmelbusch's disease.

I have, therefore, taken from our list of cured cases of cancer twenty-nine cases and placed them in the benign group. I am now restudying the cases heretofore diagnosed as adenocarcinoma-comedo and adenocarcinoma in intracystic papilloma, and I am confident that I will find in these two groups many cases that are not malignant. I must reserve this, however, for another paper.

DIFFUSE NONENCAPSULATED CYSTIC ADENOMA, KNOWN IN THE  
LITERATURE AS SCHIMMELBUSCH'S OR RÉCLUS'S DISEASE, OR  
SENILE PARENCHYMATOUS HYPERTROPHY (BLOODCOD), OR  
DIFFUSE PAPILLARY CYSTADENOMA. BB-13-8,

THIRTEEN CASES

For the gross appearance, see Figures 23 to 29; for the microscopic appearance, see Figures 39, 54, 56, 57, 61, 76, 83, 84 and 88.

Dr. William Welch, Professor of Pathology at Johns Hopkins, made a clear gross and microscopic description of this breast lesion in 1892.

Path. No. 227. In 1892, Dr. Halsted performed the complete operation for cancer on this patient. The glands showed no metastasis, and the patient is well (1921), twenty-nine years later. The clinical description made at that time corresponds to that found in all subsequent cases. It is as follows: "More than one half of the left breast is indurated, and the nipple is slightly retracted." Gross pathologic description by Dr. Welch: "Nipple not retracted; one half of the breast is filled with minute cysts and dilated ducts from which material can be expressed; about these ducts and cysts there is firm, granular tissue in which there are no white points or dots. The tissue cuts smoothly and not like cancer." Microscopic description by Dr. Welch: "Alveoli of cells and dense connective tissue with inflammation; the alveoli are lined by large epithelial cells which fill the alveoli with masses of cells and papilloma; other areas, smaller, are filled with solid epithelial cells. Diagnosis: Adenocarcinoma."

Here we have described papillary cystadenoma and solid duct adenoma. There is no note on the glands; no tissue or section have been preserved.

This patient was 42 years of age, and the tumor had been observed four months.

I described this lesion in 1899.

Path. No. 2660. The patient was a white woman, aged 43. The tumor had been present in the left breast nine months. It involved a quadrant, and one could palpate, in the indurated area, one large (1 cm.) and many shotlike nodules. At the exploration, I exposed a small blue-domed cyst, with clear



contents and smooth wall. On dividing the breast to remove this cyst, I found that it was diffusely involved, with other minute cysts containing clear fluid and granular material. There were also dilated ducts filled with pastil material. Recognizing the diffuse condition of the lesion at that time, I removed the breast. The microscopic picture of this case was reproduced in my chapter on Diseases of the Female Breast in Kelly and Noble's "Abdominal Surgery," Chapter 31, page 205, Figure 455, showing the areas of papillary cystadenoma with cystic adenoma. This patient was followed ten years, and there was no recurrence.

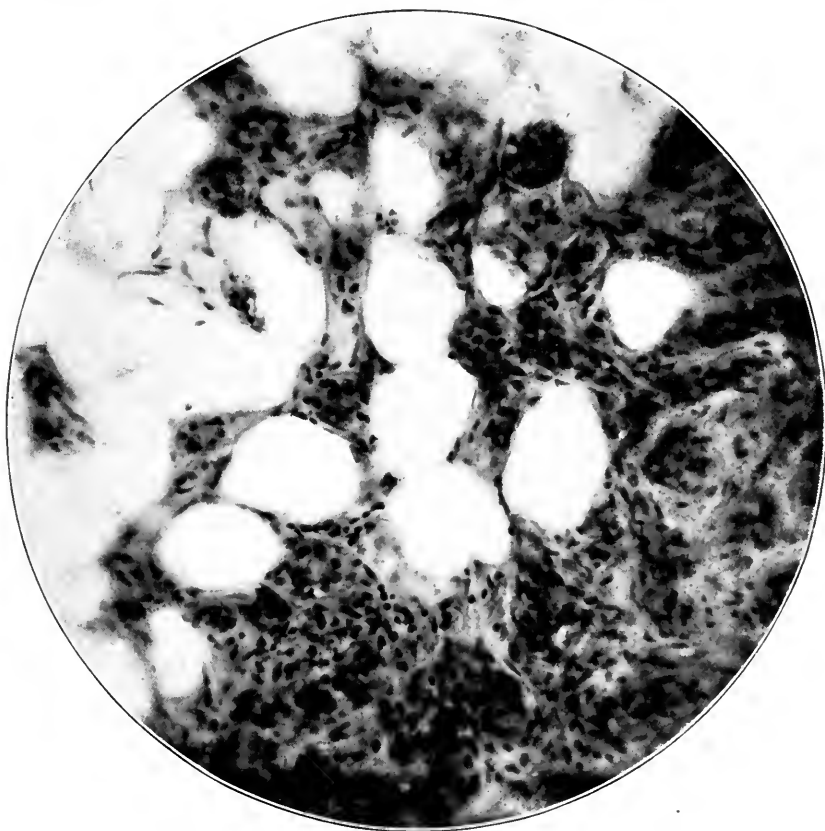


Fig. 85 (Path. No. 12586. BB-13-8 [CC]).—High power magnification of area shown in Figure 84. Small solid adenomas are apparently infiltrating the surrounding fat; but the cells are not of the cancer type. See page 534.

The third patient was operated on by Finney (1901), in Johns Hopkins Hospital. The specimen was painted by Horn (Fig. 23), and described in the gross and microscopic appearance by me.

All of us, at this time (1901), believed that we had observed a distinct clinical entity, with a characteristic gross appearance. It was not until later that I found that Dr. Welch had described it in 1892, whereas

I had described it in 1899. The painting of Finney's case (Path. No. 3965) is reproduced in colors in my chapter on Lesions of the Female Breast (Kelly and Noble's "Abdominal Surgery," Plate I, Figure 1), and is called there the adenocystic type of senile parenchymatous hypertrophy. I reproduced this picture again in 1917 (Lesions of the Female Breast, Binney's "Regional Surgery," p. 606, Figure 339) under the title "Chronic Cystic Mastitis, No Large Cysts."

Path. No. 3965. BB-13-8 (B). For the gross appearance, see Figures 23 and 24; for the microscopic appearance see Figures 54 and 83.

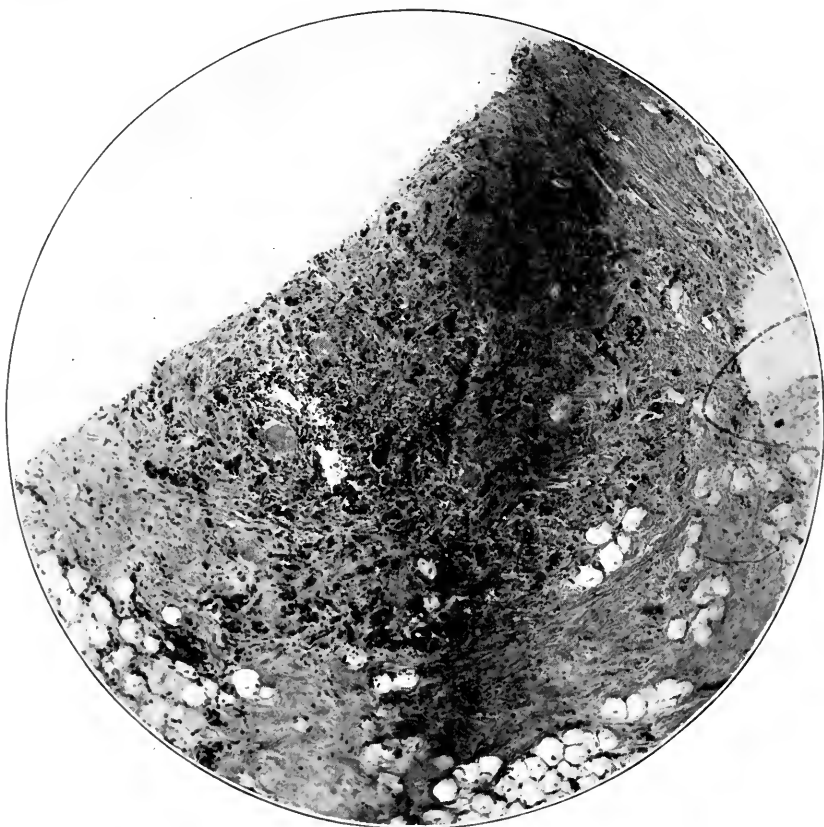


Fig. 86 (Path. No. 1147. BC-3; BB-13-7 [Expl. CC]).—Section of an area of scirrhus carcinoma in a nonencapsulated cystic adenoma. For high power magnification, see Figure 87. The malignant area was recognized by Dr. Halsted in 1895. There was no metastasis to the glands in the axilla. Result (1921): Well, twenty-six years after the complete operation for cancer. See page 520.

The clinical picture was typical. On inspection the outer hemisphere of the right breast was larger. On palpation it was felt to be indurated, like a "caked" breast. The involved area had a distinct

edge, and many shotlike nodules were felt. A brownish discharge could be expressed from the nipple.

The patient was a white, unmarried woman, aged 40. She had had pain for six months, and an enlargement for four months.

The patient would allow only removal of the breast. For the gross appearance, see Figures 23 and 24. The most suspicious areas under the microscope were those shown in Figures 54 and 83. The area from which they were taken had but 1 mm. of pectoral fascia separating it from the tissue left behind.

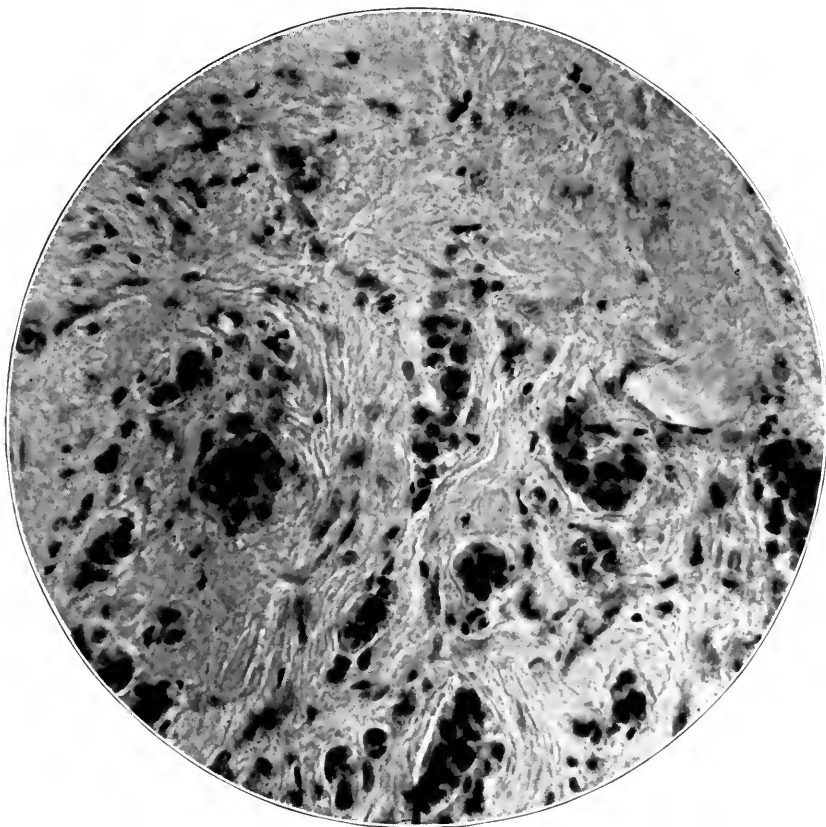


Fig. 87 (Path. No. 1147. BC-3; BB-13-7 [Expl. CC]).—High power magnification of area shown in Figure 86, scirrhous carcinoma. The nests of irregular cells are of the cancer type. See page 520.

Nineteen years later, there had been no recurrence, but the remaining breast had been removed by another surgeon in 1920. I have been unable to obtain tissue for microscopic study.

Path. No. 5221. BB-13-8 (CC). For the gross appearance, see Figure 25; for the microscopic appearance, Figure 76. The tissue in this case was brought to the laboratory in 1904 by a fourth-year student. We were informed that the patient was 47 years of age, and had had an enlargement of one breast,

involving a hemisphere, for four months. The operator first excised the breast, and then, after microscopic study with the diagnosis of cancer, performed the complete operation for cancer.

This patient was well (1921), seventeen years later. No glands were sent for microscopic study.

Path. No. 7898, BB-13-8 (B). In 1907, I received a breast specimen from Dr. Crile's clinic in Cleveland, with the typical clinical, gross and microscopic appearance of this disease; but I have been unable to obtain the result. One of my former students, Dr. Cole, who was in Dr. Crile's clinic at that time, recognized the type, and, knowing my interest, sent the specimen to me.

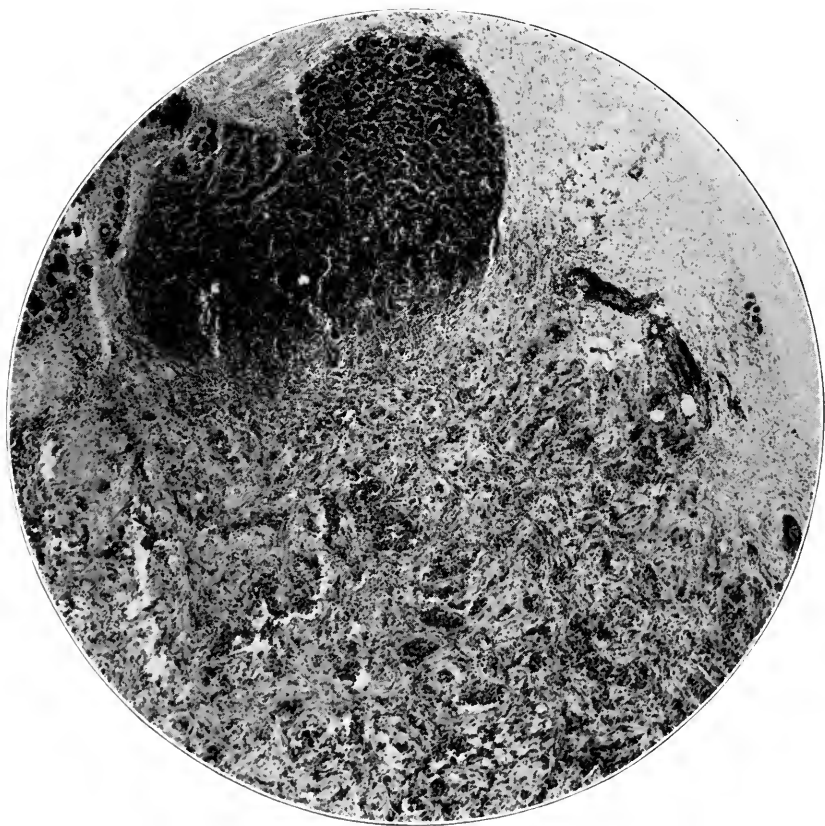


Fig. 88 (Path. No. 14115. BC-4; BB-13-8 [CC]).—An area of scirrhus carcinoma and an area of aberrant or irregular adenoma in a breast, the seat of diffuse, nonencapsulated cystic adenoma. For high power magnification, see Figure 89, for gross appearance, see Figure 28; also see page 537.

Path. No. 11125. BB-13-8 (CC). For the gross appearance, see Figures 30 and 31.

This was the third case to come under my observation. The clinical picture (Fig. 30) suggests malignancy, because over the prominent lump in the midzone of the upper and inner quadrant the skin was red and infiltrated.

Both nipples were congenitally depressed. The patient, however, had been aware of trouble in the left breast only two weeks. She was an unmarried white woman, aged 45, still menstruating. First, she had observed pain, then a lump. The redness did not appear until after the application of ice. Today, I think, I would interpret this history as an infection in a benign lesion and not as cancer (see Figs. 20*a* and 20*b* for a similar infection in a benign breast lesion).

The affected breast looked larger; there was bulging in the upper and inner quadrant as shown in the illustration. About the visible lump, this entire

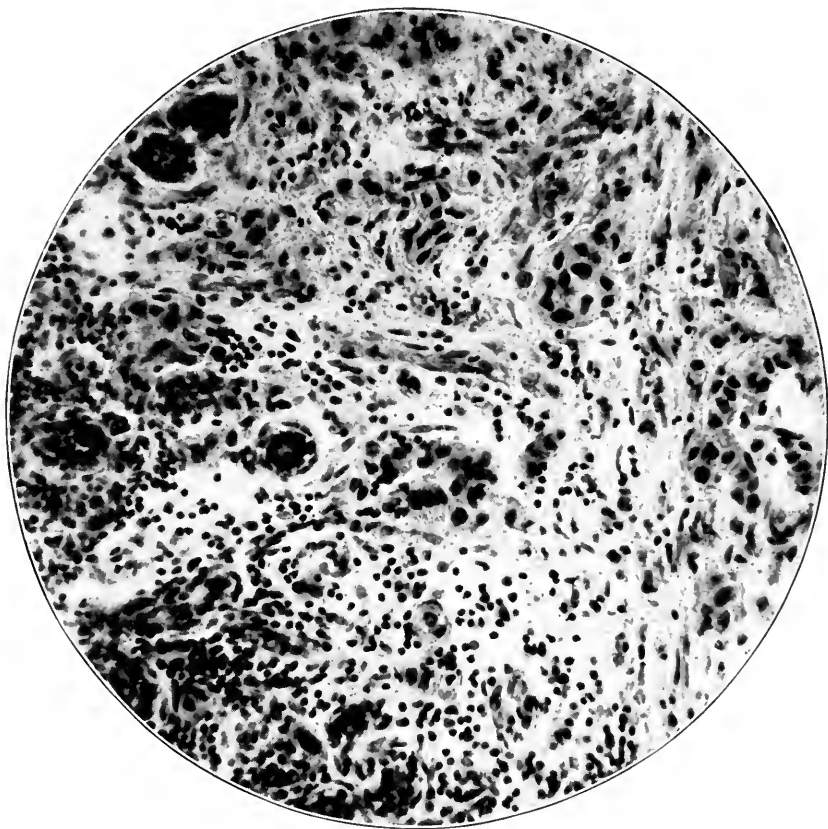


Fig. 89 (Path. No. 14115. BC-4; BB-13-8 [CC]).—High power magnification of area shown in Figure 88. The irregular nests of cells are of the cancer type, in strong contrast to the morphology and arrangement of the irregular adenomatous areas, some of the small adenoma type. See page 537.

quadrant felt like a caked breast and had a distinct edge; the red skin was infiltrated and dimpled when the breast was pushed forward. I am of the opinion today, ten years later, that I could recognize this clinically as an infection in nonencapsulated diffuse cystic adenoma. However, at that time, I performed the complete operation for cancer.

*Gross Pathology.*—Figure 30 is a reproduction of the painting from the fresh specimen. There are two cysts; the one to the right is infected, the one to the left, marked with the dissecting forceps, is a blue-domed cyst. More than one half of the breast is enlarged by increased connective tissue and riddled with minute cysts and dilated ducts, from which could be expressed a varicolored pastil material.

The microscopic sections show all the stages of chronic cystic mastitis. Papillary cystadenoma and epithelium-lined cysts predominate. The infected cyst is lined by granulation tissue, and the breast about it is the seat of mastitis.



Fig. 90 (Path. No. 17012. BB-13-7 [Expl. CC]).—Section of nonencapsulated cystic adenoma. For gross appearance, see Figure 21. Areas of cystic adenoma, a few areas of papillary cystadenoma, some solid duct adenoma. For high power magnification, see Figure 91; also page 515.

*Result* (1921).—After ten years the patient is well.

Path. No. 12586. BB-13-8 (CC). Figure 29 is the reproduction of a photograph of the patient; photomicrographs are shown in Figures 84 and 85.

*Clinical Note.*—This patient was observed by me in 1912, and represents a variation in the clinical picture which we have observed once since, that is,

*intermittent retraction of the nipple* as a symptom of onset, with the induration of the breast chiefly in the nipple and areolar zone. This patient, a white unmarried woman, aged 38, had observed intermittent retraction of the left nipple for four years, and permanent retraction for four months, while she had observed intermittent retraction of the right nipple for four months. On inspection, both nipples were retracted; on palpation, the left nipple remained retracted, while the right nipple bulged. There was indefinite induration beneath both nipples. I first performed the complete operation on the left breast, and then, three weeks later, removed the right breast, and then, six



Fig. 91 (Path. No. 17012. BB-13-7 [Expl. -CC]).—Section from nonencapsulated cystic adenoma. For gross appearance, see Figure 21; for other microscopic area, Figure 90. This area is a papillary cystadenoma somewhat resembling lactation hypertrophy. See page 515.

months later, removed the glands in the right axilla. The operation on the right side was an illogical one; but at my first pathologic examination, I interpreted this case as adenocarcinoma in chronic cystic mastitis.

This patient is well in 1921, nine years later.

*Pathology.*—In an infiltrating zone beneath both nipples there was an area of nonencapsulated cystic adenoma. The surrounding breast was senile and

fatty. The most prominent histologic picture was solid small adenoma, and I venture to describe the picture in Figure 84 as the "flower pot" lobule. These small, solid adenomas infiltrated the fat (Fig. 85).

Path. No. 13204. BB-13-8 (Expl. CC). For the microscopic picture, see Figure 61.

*Clinical Note.*—This patient also had had intermittent retraction of the nipple of eighteen months' duration when she was observed by Dr. Heuer, in 1912. At the examination, the retraction of the nipple was permanent. The patient was a widow, aged 49. She had observed the nipple of the left breast to pull in and then protrude, off and on for eighteen months. There had been no discharge from the nipple. She sought advice because of pain of four months' duration. On palpation, nothing very definite was made out. Dr. Heuer explored and was of the opinion that the breast beneath the nipple was the seat of cancer. He immediately performed the complete operation. The breast, when received in the laboratory, had been much cut up, but I found, similar to Path. No. 12586 (Fig. 29), a zone of nonencapsulated cystic adenoma beneath the nipple. The surrounding breast was fatty and senile. The most suspicious microscopic areas are shown in Figure 61—small, irregular stellate solid adenoma with some cystic adenoma. The glands showed no metastasis.

*Result.*—This patient returned two years later with a similar clinical picture in the right breast—intermittent retraction of the nipple of one year's duration, permanent retraction for the last three months. On palpation, indefinite lumps were discovered in this breast. Dr. McClure, the resident surgeon at Johns Hopkins, because the diagnosis of adenocarcinoma in chronic cystic mastitis was still unchanged, performed the complete operation for cancer. The gross and microscopic pathology of this breast was practically identical with that in the breast removed at the first operation.

This, therefore, is our second observation of intermittent retraction of the nipple as a symptom of onset of this form of chronic cystic mastitis. In both cases, ultimately both breasts were involved.

Path. No. 16431. BB-13-8 (CC). I received sections from this breast from an outside source. It had been diagnosed clinically as cancer, and the complete operation was performed. There has been no recurrence in 1921, seven years later.

Path. No. 20457. BB-13-8 (CC). For the microscopic picture, see Figure 57.

This case is interesting because the left breast had been subjected to the complete operation for cancer by me in 1914. The lesion proved to be diffuse comedo-adenoma with no areas of cancer and no metastasis to glands.

I removed the right breast in 1916, two years later, because of pain and an indefinite nodule beneath the nipple. At that time I was still calling diffuse comedo-adenoma, adenocarcinoma; and, in view of the fact that a woman who had been operated on for malignant tumor of one breast runs a greater risk of cancer (almost 10 per cent. more) in the other breast, I removed the latter. Its gross pathology was that of diffuse nonencapsulated cystic adenoma, and the predominant histologic picture was papillary cystadenoma in the ducts (Fig. 57).

This patient was well (1921), seven years after the first operation.

Path. No. 20046. BB-13-8 (BB). For the gross appearance, see Figure 27; for the microscopic appearance, see Figures 39, 40, 41 and 42.



*Clinical Note.*—This was my first observation of the lesion involving both breasts without retraction of the nipples. The entire breast was involved, and each presented the identical sensation to palpation. One could palpate the edge of each breast throughout its circumference. The entire breast was indurated as in mastitis, with some shotlike nodules. The nipples were not retracted. The patient was a white unmarried woman, aged 43, still menstruating. She asserted that both breasts had been lumpy for years. During the last month, the lumps had become larger and had fused, so that now she could not pick out a single lump. There had been pain in both breasts for two weeks.

I made the clinical diagnosis of this type of chronic cystic mastitis and removed both breasts.

The gross pathology (Fig. 27) is the same in both breasts, and resembles closely that shown in Figure 23.

The predominant histologic picture is minute cysts, cystic adenoma and small solid adenoma (Figs. 39, 40, 41 and 42).

*Result* (1921).—One year later the patient was well.

Path. No. 26439. BB-13-8 (CC). For the gross appearance, see Figure 26; for the microscopic appearance, Figure 56.

I examined this patient with my colleague Dr. Seegar at St. Agnes Hospital in July, 1920. The lesion completely involved one breast only. The nipple was not retracted, nor had there been discharge from it. I advised the complete operation, which was performed. The gross pathology (Fig. 26) was a little unusual—minute cysts and dilated ducts with yellow and green material were not so prominent a feature as in Figures 23 and 27; but the surface of the breast presented small irregular, granular alveoli, as described by Welch in 1892 (p. 528) and the predominant microscopic picture was papillary cystadenoma in ducts (Fig. 56).

#### CANCER AND DIFFUSE NONENCAPSULATED CYSTIC ADENOMA

Path. No. 14115. BC-4 and BB-13-8 (CC). For the gross appearance, see Figure 28; for the microscopic appearance, see Figures 88 and 89.

*Clinical Note.*—In 1913, Dr. Finney at Union Protestant Hospital performed the complete operation for cancer on this patient and sent the specimen to my laboratory. It was his opinion that clinically and in the gross the disease was cancer. The history sent with the specimen was very brief: "White, unmarried female, aged 39; symptom of onset enlarged glands in the axilla eleven months; lump in the affected left breast, one month; lump in the right breast, one month." A gross section of the breast is shown in Figure 28. When I examined this breast, the palpation was typical of this form of chronic cystic mastitis. The entire breast was involved, indurated, with many minute shotlike nodules; but portions of the breast felt almost as hard as cancer. On section, there were a few minute cysts and dilated ducts; but the most marked feature was increased fibrous stroma with granular alveoli, and one or two small areas which felt and looked like cancer. These areas are shown in Figures 88 and 89, and picture scirrhous carcinoma and an area of aberrant or irregular adenoma. The axillary glands showed metastasis. Other areas of the breast showed a few epithelium-lined cysts and dilated ducts, cystic adenoma, irregular adenoma, aberrant adenoma.

*Result.*—Death occurred in ten months from metastasis to the brain. There was local recurrence in the scar before death.

*Comment.*—Enlarged glands in the axilla as the symptom of onset in cancer of the breast are a very rare observation. I cannot recollect more than three cases. Apparently, Dr. Finney made the diagnosis of malignancy from the palpation of these glands. It is the only case of cancer which I have had the opportunity to observe and in which the cancer was almost a microscopic area. But this case seems to show that cancer *may* develop in this type of chronic cystic mastitis, one out of thirteen cases—about 8 per cent.—while among eighteen cases of nonencapsulated cystic adenoma (BB-13-7 occurring as a small palpable tumor), there has been one example of cancer easily recognized in the gross—about 6 per cent.

*Cancer and Chronic Cystic Mastitis.*—I mentioned this in the beginning of my article; but I find that I have neither time nor space to describe it in detail. We have restudied all the cases of fully developed cancer in relation to the condition of the surrounding breast; but this investigation is not quite completed, so that I am unable to give the exact figures; but I am confident that when the study is finished, the conclusion will be that the predominant picture of a breast the seat of cancer is senile.

BB-12-1.—On three occasions, we have observed blue-domed cysts and some chronic cystic mastitis in a breast removed for cancer; but in these cases neither the cyst, nor the chronic cystic mastitis was made out until after the complete operation had been performed and the breast sectioned. The cyst as a tumor had never been observed by the patient.

BB-12-2.—As yet we have not found a cyst of the galactocoele type associated with cancer of the breast.

BB-12-3.—We have never observed cancer in the diffuse cystic disease of the breast. This conforms to the observations of Billroth, Velpeau, and all the older authorities, which I have read with great care.

BB-13-4 and 5.—In a large number of breasts completely removed for cancer, we have noted increased parenchyma in adenomatous areas, here and there a minute cyst, or one or more dilated ducts. But this condition of the breast had presented no clinical symptoms.

BB-13-6.—The extreme degree of dilatation of the ducts beneath the nipple, presenting itself clinically as a palpable wormlike mass beneath the nipple, has never been observed in association with cancer of the breast. On a few occasions, the ducts beneath the nipple have been slightly dilated and filled with the characteristic material; but the malignant tumor has been outside this zone, and there has been nothing to palpate beneath the nipple in these cases.

BB-13-7.—I have already noted and described one case of scirrhus cancer and cystic adenoma. There have been a few more, all of which were recognized, either clinically, or in the gross, as cancer, and treated as cancer.

BB-13-8.—I have illustrated and described one case of cancer in the diffuse nonencapsulated cystic adenoma. There are a few other observations; but in all, the lesion was clinically malignant, the complete operation performed, and this type of chronic cystic mastitis found in making a gross section of the breast.

Microscopic areas which may be called chronic cystic mastitis are not uncommon findings even in the senile breast.

Among the 350 cases of chronic mastitis, my evidence seems to show that if the palpable single or multiple lesion can be recognized in the first six groups, which include 319 cases, the breast can be saved without the patient running any more risk of cancer than is incidental in any woman at the same age.

In regard to groups BB-13-7 and -8, in the small isolated and the diffuse nonencapsulated cystic adenoma, lesions easily to be differentiated from the others, it might be safer for the present to perform the complete operation for cancer.

*Conservative Operation for Chronic Cystic Mastitis of the Types 1 to 6.*—As a matter of fact, among the 319 patients subjected to operation in these six groups, conservative operations have only been performed in 128 cases, about 38.5 per cent. Of these 128 conservative operations, I have performed sixty-two, or 47 per cent., while my colleagues at Johns Hopkins are credited with thirty-two cases, and outside surgeons with thirty-four cases.

The most common type of chronic cystic mastitis to be subjected to the conservative operation is BB-12-1, the blue-domed cyst—ninety-three cases (Bloodgood forty-nine, more than 50 per cent.; Johns Hopkins, twenty-five; outside surgeons, nineteen).

Further discussion as to the relation of the extent of the operation to the clinical picture and pathology at exploration will be postponed for a second paper.

The present paper deals with the most important feature of the diagnosis—pathology; and I trust that it will aid operators and pathologists to recognize more frequently the types of chronic cystic mastitis.

#### THE MICROSCOPIC PICTURE OF THE DIFFERENT TYPES OF CHRONIC CYSTIC MASTITIS

*Classification.*—The following classification is based on the study of hundreds of sections and is an attempt to describe the different histologic pictures using the simplest nomenclature which had been

previously employed in the literature and textbooks. When more than one term has been used to describe apparently identical pictures, I have tried to select the one most frequently in use.

Main Division.

- I. Adenomatous.
- II. Cysts.
- III. Dilated Ducts.
- IV. Papillary Cystadenoma.
- V. Solid Adenoma.
- VI. Mastitis.
- VII. Changes in the Basement Membrane.
- VIII. Changes in the Basal-Cell Arrangement.
- IX. Changes in the Morphology of the Cell.
- X. Changes in the Stroma.

All the histologic pictures seen in chronic cystic mastitis and in all benign lesions of the breast can be described within these nine main divisions.

Subdivisions.

- I. Adenomatous.
  1. Normal (Fig. 32).
  2. Lactation (Fig. 33).
  3. Senile (Fig. 34).
  4. Fibro-adenomatous (Fig. 35).
  5. Intracanalicular (Fig. 36).
  6. Aberrant (Figs. 37 and 52).
  7. Irregular (Fig. 38).
  8. Cystic (ectasia) (Figs. 39 and 43).
- II. Cysts.
  1. Large cysts, no epithelial lining (Fig. 44).
  2. Large cysts, epithelial lining (Figs. 45 and 46).
  3. Small cysts, epithelium-lined (Figs. 47 and 48).
- III. Dilated Ducts.
  1. Small dilated ducts, almost normal (Figs. 32, 35 and 37).
  2. Large (Figs. 49, 50 and 78).
  3. Small ducts with thickened walls, residuum from old mastitis (Fig. 34).
- IV. Papillary Cystadenoma.
  1. Isolated in lobule (Figs. 52 and 53).
  2. Diffuse, alveolar (Figs. 55, 70, 72, 73, 74, 76, 77 and 91).
  3. In ducts (Figs. 56 and 57).
- V. Solid Adenoma.
  1. Small alveolar (Figs. 39, 40, 58 and 63).
  2. Large, apparently in ducts (Figs. 59, 60, 79, 81 and 90).
  3. Small irregular stellate (Figs. 41, 61, 79 and 80).
  4. Comedo (not observed in chronic cystic mastitis).

## VI. Mastitis.

1. Alveolar with atrophy (Figs. 44, 62 and 67).
2. Alveolar with solid adenoma (Figs. 62 and 63).
3. Periductal (Figs. 34, 64, 65, 66 and 78).
4. Diffuse; interstitial (Fig. 67).
5. Zones of granulation tissue (Figs. 67 and 68).
6. Giant cells (Fig. 67).
7. Tubercles (none found in chronic mastitis).
8. Organized hematoma (Fig. 69).

## VII. Basement Membrane Changed.

1. Intact (Figs. 32, 33, 35, 36, 39, 45, 55, 57, etc.).
2. Destroyed or atrophied, partially or completely (Figs. 42, 62, 66, 71, 73, 74, 75, 76, 77, 79, 81, 83 and 85).

## VIII. Basal-Cell Arrangement.

1. Normal in all the figures noted after VII-1, basement membrane intact.
2. Abnormal in most of the figures noted after VII-2, basement membrane destroyed; most marked in 66, 75 and 82.

## IX. Morphology of the Cell.

1. Basal—resting (Figs. 32, 35, 36, 38, 59, 60, 61 and 72).
2. Glandular—active (Figs. 33, 53, 54, 55, 56, 57, 74 and 82).
3. Atrophic—degenerating (Figs. 34, 62 and 79).
4. Proliferating and desquamating (Figs. 51, 56, 66, 77 and 78).
5. Suggestive of the cancer type (Figs. 76, 77 and 82).

## X. Fully Developed Cancer. (Figs. 86, 87, 88 and 89).

*Comment on the Microscopic Picture.*—It is important to record that the histologic pictures shown in Figures 33 to 85 and in 90 and 91 have never been observed in the breast of a patient whose glands showed metastasis, or who had definite cancer. Similar microscopic pictures are to be found in the encapsulated adenoma (fibroadenoma, intracanalicular and cystic); in the intracystic papilloma, in diffuse virginal hypertrophy; in mastitis associated with lactation, unassociated with lactation, and in tuberculous mastitis.

Most of these microscopic pictures have been observed in the breast tissue surrounding a blue-domed cyst, in which the cyst and a zone of breast tissue had been removed; and yet, there has been no recurrence nor the development of cancer after many years' observation of the patients.

In the breast surrounding the blue-domed cysts, certain microscopic pictures are uncommon such as those shown in Figures 55 and 73.

Certain microscopic pictures have been observed only in BB-13-7 and -8, the isolated and diffuse nonencapsulated cystic adenoma, for example, Figures 56, 74, 76, 77; but similar pictures have been seen in the encapsulated cystic adenoma.

*Characteristic Histologic Pictures.*—Figure 32 shows an almost normal breast; Figure 33 is lactation hypertrophy; Figure 34 in its thick-walled ducts indicates an old mastitis of years' duration; Figure 36 is

an intracanalicular myxoma; Figure 44 is the thick wall of a large cyst; Figure 45 is typical of a duct; Figure 48 is characteristic of the diffuse cystic disease of the breast; Figure 49 of diffuse dilatation of the ducts beneath the nipple; Figure 56 is almost characteristic of the diffuse nonencapsulated cystic adenoma in which papillary cystadenoma of the duct predominates.

*Where Pathologists Disagree.*—I have submitted sections of every type of chronic cystic mastitis, lactation mastitis, tuberculous mastitis, encapsulated cystic adenoma, fibro-adenoma, and intracystic papillomas to more than forty consulting pathologists, and I have their written diagnoses. In the majority of these cases, there was disagreement; the percentage of those favoring benignity varied from twenty to ninety.

In all of these demonstrations, the sections illustrated in Figures 87 and 89 were included. On these two cases of fully developed cancer, there was not a single disagreement.

During the same period, many sections and tissues have been sent to me from other surgeons and pathologists with their diagnoses. I have never received one which proved to be a fully developed cancer that had not been diagnosed cancer. But I have received many with a diagnosis of cancer which in my opinion belonged to one of the above mentioned benign groups.

It is very interesting to record here again that in breast lesions, when good pathologists disagree as to malignancy, the patient lives; when there is agreement, there is always a large percentage of deaths from cancer.

#### CONTRIBUTIONS OF THE AUTHOR TO THE LITERATURE ON BREAST LESIONS

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# THE ACHIEVEMENTS AND LIMITATIONS OF NEUROLOGIC SURGERY\*

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In my lifetime, the history of neurologic surgery has been written, and the most important events have occurred in half that time. In limiting the development of this special field to this period, I am not unfamiliar with the fact that trephination was an accepted surgical procedure years before the days of Hippocrates, the Father of Medicine, when the Egyptians trephined the skull for migraine and epilepsy, and that in the second century, Galen, whose favorite field of investigation was the nervous system, advocated sundry operations for injuries to the brain. He was familiar with the clinical picture of cord compression and recommended operation for its relief. While from Galen's time to the days of modern medicine, there have been isolated instances of operation, dealing with the nervous system, mostly for the relief of traumatic lesions, the growth and development of neurosurgery along broad lines and in an ever-widening zone of lesions did not occur until our own day; until the indications for surgical interference so multiplied as to command the attention of those who could give it their exclusive time and thought. Thus, in time, neurosurgery became recognized as a surgical specialty.

In passing so hastily from Galen's to our own time, we should not forget that Broca (1824-1880) has been acknowledged as the founder of modern surgery of the brain. Broca was the first to trephine for the evacuation of cerebral abscess, which had been diagnosed by his theory of localization of function. His discovery of the center of articulate speech—Broca's region—in the third left frontal convolution laid the foundation for cerebral localization. But I have always pictured the era of surgical neurology as beginning with the work of Sir Victor Horsley. How fortunate it was that the pioneer in this field should have embodied all qualifications that even now we conceive as ideal: he was the experimentalist, the neurologist, the surgeon, all in one. If we were to outline a course in preparation for the practice of surgical neurology, we could do no better than to use Horsley's life and activities as the prototype. His fundamental knowledge of neurology, his enthusiastic pursuits in the experimental laboratory, especially in brain localization, his ingenuity in matters of surgical technic were the foundation stones of his brilliant career.

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In 1886, Horsley performed the first successful operation for the removal of brain tumor, and from that time on, brain tumors have been one of the larger, if not the largest, problems of the neurologic surgeon. The mechanics of cranial exploration have been mastered; but the management of the individual case after the cranial cavity has been opened taxes the resources of the operator, and to carry it to a successful issue implies an intimate knowledge of the causes of increased intracranial pressure and the manner of dealing with them, of the sources of hemorrhage and how to control it, of the naked eye appearance of normal and pathologic brain tissue, of the limitations of surgical intervention and the recognition at the operating table of what constitutes an operable and what an inoperable lesion.

We have outlived what used to be called the "expectant treatment" of tumors, a screen behind which the physician concealed his inability to make a diagnosis. Contrary to the general impression, gummas of the brain are exceedingly uncommon. I have seen but two in my clinic, and, with the greater aids to diagnosis, there is now no excuse for that indefinite course of iodids and mercury. I hoped to outlive this practice; at least, I have lived to see it on the wane.

#### TYPES OF TUMORS AND THEIR TREATMENT

We have come to recognize distinctive problems in different types of tumors. There is as much difference between an endothelioma and a glioma as between a gastric ulcer and an infiltrating carcinoma of the wall of the stomach. The former are definitely encapsulated tumors, and, taking their origin from the membranes, are readily accessible except at the base of the brain. Fortunately, they have been more frequent than the gliomas in our clinic; the proportion of the endothelioma group to the glioma group has been as 6 to 4, in those cases in which the tumor has been exposed on the operating table. The size of the tumor is relatively unimportant (Fig. 1). Not only from the standpoint of operability, but of immediate mortality, must endotheliomas be considered quite apart from gliomas. In the latter, sharpness of definition is often lacking. By replacing normal brain tissue without adding to the volume of the cranial contents gliomas often grow to large dimensions before there are signs of intracranial pressure and the surgeon is consulted. (I must qualify this statement by admitting exceptions. Only within the year have I seen two tumors, grossly appearing as endotheliomas, sharply defined and encapsulated, but having the microscopic characteristics of gliomas [Fig. 2].)

To illustrate this distinction between the glioma and endothelioma I have compared the last ten cranial explorations for endothelioma with the last ten cranial explorations for glioma. In the endothelioma



series, the lesion was regarded as operable in all, and there was but one fatality. In the glioma series, but one of the ten was considered operable and five of the ten patients succumbed to the mere effects of exploration. Mere exploration in the glioma is attended with a risk peculiar to this lesion. Following the operation, an edema develops, or hemorrhage in the tumor from a ruptured blood vessel ensues. The patient, soon or immediately after the operation, may pass into a stupor, gradually deepening, until within from twenty-four to forty-eight hours the end comes (Fig. 3). One sees the brain

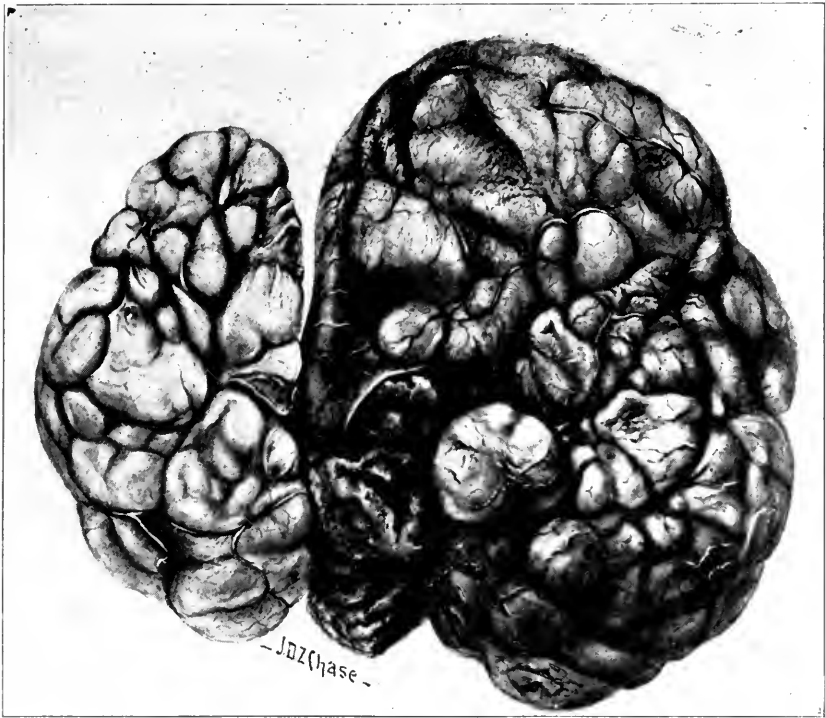


Fig. 1.—Tumor, 13 by 10 by 6 cm., after removal from frontal region of a boy, aged 6 years.

begin to swell soon after the dural flap is reflected, and it continues so to increase in bulk within the time of exploration that closure of the flap either is attended with great difficulty or is impossible. This process of edema develops in the gliomas not only when the pressure conditions are altered by reflection of an osteoplastic flap, but even by the establishment of a decompressive opening, so that one must be prepared for a fatal issue, even after an operation of itself so comparatively free from danger as the subtemporal decompression.

It is essential that one should be able at the operating table to distinguish between a lesion which may be said to be operable and one which is inoperable. It is in this connection that judgment and experience count. The tolerance of the brain to exploration, when disturbed by conditions of increased intracranial pressure, must be appreciated. The operator can learn only by experience what constitutes operability and inoperability and must be willing and ready to recognize barriers, when confronted with tumors, to successful or satisfactory extirpation. In the consideration of the surgical problems of brain tumors, a discussion in general terms is fruitless and misleading. Differences in location and differences in tumor types are such as to demand, in an intelligent discussion of relative values, whether it be in matters of diagnosis, in matters of technic or in end-results, a subdivision or classification. Such a classification should recognize as distinct neurosurgical problems: I. Pretentorial lesions:



Fig. 2.—Glioma immediately after removal, showing its encapsulation.

(a) endotheliomas; (b) gliomas, and (c) pituitary lesions. II. Subtentorial lesions: (a) pontile angle tumors; (b) "acoustic" tumors, and (c) hemispheric and intrahemispheric tumors.

A further distinction should be made in reports published under the general heading of brain tumors between those "verified" by examination of specimen removed on the operating table or at necropsy. All other cases should be considered in a group by themselves as "unverified."

#### PSEUDOTUMORS, SO-CALLED

I have seen in these years a group of cases, call them what you will, in which a preliminary diagnosis of tumor was made which failed to be confirmed at the operation; and yet, after the relief of pressure,

the symptoms have subsided and the subsequent course of events has eliminated the possibility of the existence of a growth. Objections have been made to the term "pseudotumor" and its recognition as a clinical entity, and quite properly; but the existence of this non-descript group, with the possibilities not only of relief from headache and vomiting and of the conservation of vision but also of complete recovery, is, to my mind, one of the strongest arguments in favor of decompressive operations. In all probability, the underlying pathologic condition in these cases simulating tumor is a meningitis or leptomeningitis. The onset is so insidious that it is difficult to determine the source of infection, but, it has been my belief that the exanthematous and infectious fevers are in many instances the responsible factors, particularly whooping-cough, measles and influenza. The case herewith reported is an instance in point:

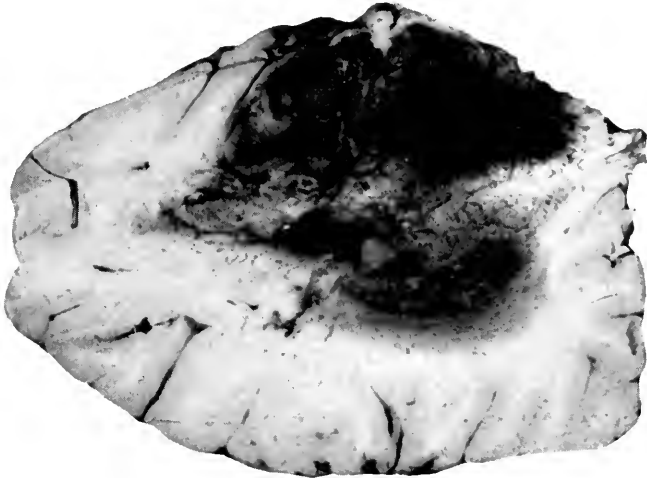


Fig. 3.—Subcortical glioma, showing vague, indefinite outline as the tumor infiltrates the surrounding tissue, a typical inoperable growth.

CASE 1.—M. L. F., aged 22 years, was admitted to the Neurosurgical Service of the University Hospital, Nov. 27, 1919. She had had influenza in October, 1918. In May, 1919, she began to complain of headache, frontal and occipital, which gradually became most intense, and in October it was associated with vomiting. Later she noted tinnitus in the right ear. She was subject to attacks of vertigo, and she could not preserve her equilibrium when standing or walking. Examination of the eye grounds revealed a papilledema of +5 diopters in each eye. A preliminary diagnosis of tumor was made; but there were not enough physical signs to warrant its localization. A right subtemporal decompression was performed, Nov. 28, 1919: there was a decided increase in intracranial pressure; but on opening the dura, a considerable amount of cerebrospinal fluid escaped and before closure of the wound the tension had subsided appreciably.

Feb. 19, 1920, Dr. deSchweinitz reported that the choked disks had subsided markedly, and, Dec. 2, 1920, the choked disks had practically disappeared.

Meanwhile the patient has completed the studies of the senior class at college and has acquired a bachelor's degree. She is now symptom-free (Fig. 4).

#### SUBTEMPORAL DECOMPRESSION

We must revise our earlier conception of the value and source of decompressive operations, and particularly the subtemporal decompression. Its greatest sphere of usefulness was thought to be as a palliative measure in tumors recognized as inoperable. As a matter of fact, its greatest sphere of usefulness is really first in cases without tumors, such as the case above reported and, secondly, in cases in



Fig. 4.—Patient, one year after subtemporal decompression. She had fully recovered from the symptoms suggestive of tumor. The underlying pathology was probably meningitis or leptomeningitis.

which the existence or location of the tumor is in doubt, and the operation is employed as one of temporary expedience, in the hope that continued observation may reveal the true nature of the lesion.

While not deprecating subtemporal decompression in tumors recognized as inoperable—one frequently must resort to it though recognizing its limitations—we must acknowledge a disappointment in the duration of the relief it affords, and the reason of this is obvious. We now

know, what at first we did not realize, that the size of the hernia, established at the site of the opening has no relationship to the size of the growth, nor is the increase in the size of the hernia proportionate to the rate of growth of the tumor. The decompression opening affords an opportunity for the ventricles to dilate and the space presumably provided for the relief of pressure, occasioned by the growth, is soon appropriated by the dilated ventricle (Fig. 5).

As internal hydrocephalus is so frequent an accompaniment of brain tumor, no matter where its location, I frequently combine ventricular drainage by callosal puncture with subtemporal decompression. By this combination, a two-fold purpose is served. There is less likelihood of laceration of the cortex when the dura is opened under conditions of extreme intracranial pressure, and the measure of



Fig. 5.—Drawing from a specimen with an internal hydrocephalus, illustrating the effects of a subtemporal decompression. Note how much of the hernia at the site of the decompressive opening is represented by the dilatation of the ventricle.

relief of pressure thus afforded is greater and of longer duration. In course of time, variable to be sure, the opening in the corpus callosum unfortunately closes.

#### MAJOR TRIGEMINAL NEURALGIA

It is just twenty years since the first purposeful section of the sensory root of the gasserian ganglion, after the proposal of Spiller, was performed for the relief of trigeminal neuralgia. It was not until a year's investigation in the experimental laboratory proved the

soundness of the suggestion that I undertook the operation in my clinic. Since that time, of the 554 patients I have seen with trigeminal neuralgia, I have performed the Spiller operation 218 times and have seen the mortality reduced first to 5 per cent., then to 3.5 per cent. and now to less than 1 per cent. In the last 177 cases there has been but one operative death. In every respect, it is the most satisfactory of operations and has reached a stage of refinement that makes one feel that this chapter in neurologic surgery might be considered closed. Recently I have been able, by a modification in technic, to conserve the motor root and in so doing to prevent the atrophy of the temporal, masseter and pterygoid muscles, a matter of considerable importance, both because of the cosmetic result and



Fig. 6.—Characteristic sella deformation of a primary intrasellar lesion. The primary lesion in this case, however, was a suprasellar tumor—an endothelioma of the optic nerve. Compare with Figure 7.

because of the greater ease with which the patient can masticate food. The time is now past when a patient suffering from this most intolerable of neuralgias should not be given immediate relief. Alcoholic injections in practiced hands give immediate, though transitory, relief. These, or the major operation, are the alternatives. There are no substitutes. Needless to say, these dogmatic statements apply only to the major or epileptiform neuralgias of the trigeminal nerve. I hear and read much about sinus disease and focal infections as etiologic factors of the major types. I can recall but two cases in which sinus disease seemed to bear any relationship to the pain, and in both these cases the clinical picture was not that of the major form.

Not to be misunderstood, I repeat that what I have said of treatment applies to what I have called the major trigeminal neuralgia, a term we should adopt by common consent, in all dissertations or discussions, to mean that particular form of neuralgia first described by Fothergill. Its recognition is not difficult. But we must not forget that there remain, exclusive of the major form, a great many pain phenomena in the zone of the trigeminal nerve, some of which



Fig. 7.—Patient (right) with acromegalic symptoms.

do not originate in any lesion of the trigeminal tract. Here is a fruitful field for investigation that brings in, among other things, the part that the sympathetic system may play. I am not referring here to the neuralgias that may arise from any infective focus, from herpes or from tumors.

## SURGERY OF THE PITUITARY BODY

As Murphy, with his button, opened up the field of gastro-intestinal surgery, so Hirsch, of Vienna, with his transsphenoidal approach first revealed the possibilities of a surgical approach to the pituitary body. Credit should be given to Schloffer, who, in 1907, performed the first successful operation on the pituitary body. We have come to recognize two methods of approach, the transsphenoidal and the transfrontal, and when I described my transfrontal method of approach, in 1912, I was disposed to advocate this as the method of choice, but since then my views have been revised. There is no doubt that when, as is so often the case, the lesion has extended well beyond the confines of the sella and is as much suprasellar as intrasellar, an adequate exposure and an attempt at radical removal are possible only by the intracranial approach.

The deepening of the sella turcica indicates downward growth, but gives no clue to the upward intracranial extension. Before the posterior clinoid processes are destroyed, the lesion has often broken



Fig. 8.—Drawing of endothelioma removed from the upper thoracic cord of a patient who had had symptoms for four years. The patient was still able to walk and there was only partial loss of sensation.

through the diaphragm and become an intracranial growth. And even a sellar decompression will not retard the growth upward. Then too, we must remember that the sellar deformation and the clinical picture may be very misleading. I have had under my care patients in whom the sellar deformation and the symptomatology were quite characteristic of a primary intrasellar lesion. And yet at operation the primary lesion was found to be a suprasellar growth. The pituitary disturbances were secondary (Figs. 6 and 7). But, admitting its theoretical advantages, the intracranial suprasellar operation is a very much more formidable procedure, and in view of the fact that in most instances life is not threatened by the lesion itself, so often a benign adenoma or a hyperplasia, the more serious of the two operations should be reserved for the final rather than the initial step in the surgical program. It is interesting to note that in the last two years we have had no fatalities following the transsphenoidal method.



Manifold as are the clinical evidences of a disturbed pituitary function, the paramount indications for surgical intervention, after all, are disturbances of vision and headache, both pressure phenomena. The simple sellar decompression, while in no sense a radical operation, meets the immediate requirements, and, if performed before optic

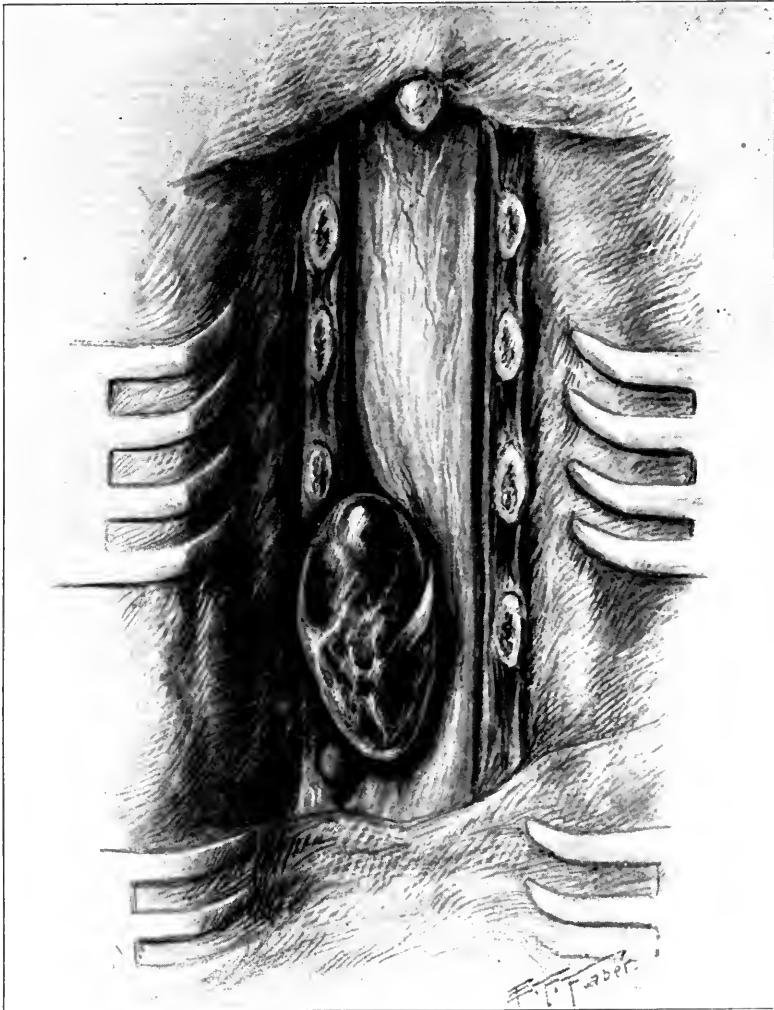


Fig. 9.—Drawing, at operation, of an extramedullary endothelioma. Three weeks after its removal, sensation was restored and the patient was able to walk.

atrophy is too far advanced, will be followed by an almost immediate restoration of the contracted visual fields to normal. And since we have found that radium and roentgen rays have a retarding influence

on the growth of the pituitary lesion, we have in these agencies some assurance against the recurrence that often follows the sellar decompression.

#### TUMORS OF THE SPINAL CORD

Spinal cord tumors, for obvious reasons, present fewer difficulties as to diagnosis, localization and exploration than brain tumors. In looking over my records, I find there were but three instances in which the tumor was not found, twice because of errors in diagnosis and once because of an error in technic. The restrictions as to space within the bony canal limit the size of the tumor and at the same

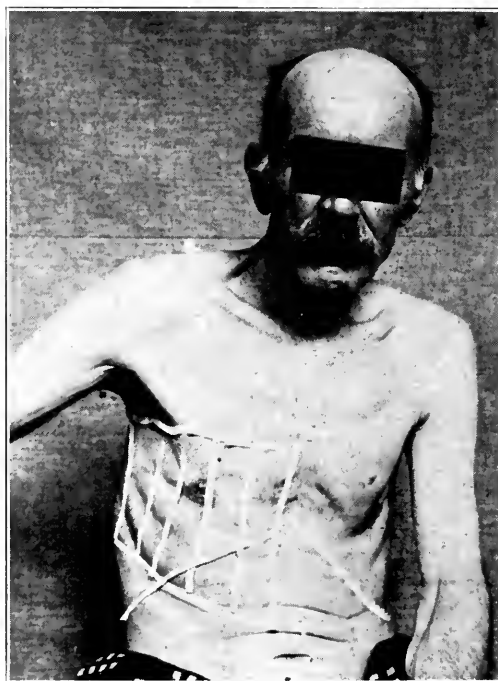


Fig. 10.—Patient after resection of the posterior roots of the seventh, eighth, ninth and tenth thoracic segments of the spinal cord. The area of anesthesia is included within the markings.

time facilitate the problem of exploration. Extramedullary tumors fortunately are more common than intramedullary growths and the majority of these are encapsulated. The relation between the various cord segments and their roots to the cutaneous segments, on the one hand, and their muscular terminations, on the other, is so definitely established that accurate localization is the rule. All these are factors which make spinal cord tumors so favorable for surgical intervention. I have been impressed with the number of cases in which the clinical

history and the syndrome do not conform to type, in one particular or another. It may be that pain is absent; it may be that in the history one cannot trace the three characteristic cycles: (1) of root irritation, (2) of the Brown-Séquard syndrome, (3) of vesicorectal involvement; whatever it is there are enough atypical cases to justify an appeal for earlier exploration in doubtful cases. There has been too much procrastination, while waiting for absolute and confirmatory evidence. It is surprising how the clinical picture may vary when the lesions are almost identical. I recall two recent instances in which tumors were found of almost equal dimensions. In one there was a complete paraplegia; in the other, with a clear history of four years' duration, the patient was able to walk, though handicapped more by

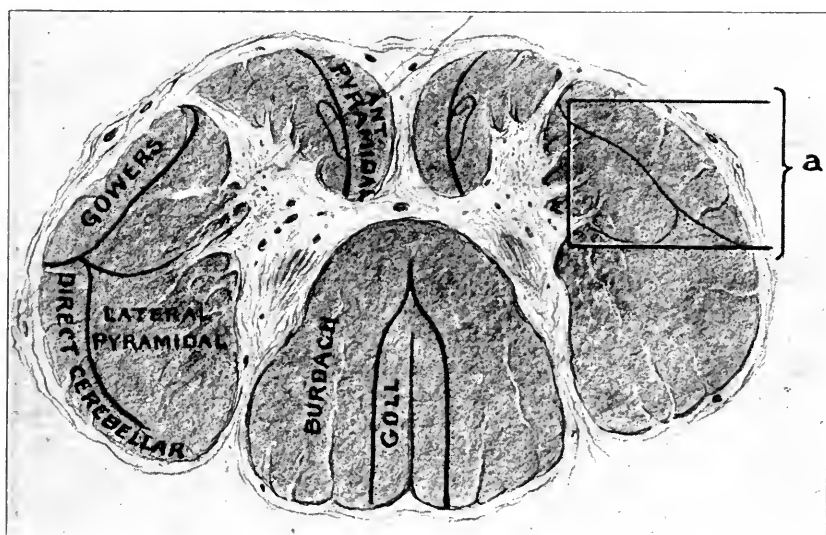


Fig. 11.—The spinal cord at the level of the sixth thoracic segment. Cutting the anterolateral columns of the cord, as described, implies section of that portion of the cord included in the area marked *a*.

spasticity than by weakness. I was in great doubt as to the propriety of operation, and yet we found a relatively large endothelioma (Fig. 8).

We have been too cautious in the spine, as in the cranial cavity, in our attitude toward exploration. Given a case of a complete or partial transverse lesion of the cord that cannot be explained satisfactorily on a basis other than tumor, even though the tumor picture is not clear, an exploratory laminectomy should be undertaken without hesitation. Too often are we called on to operate on patients with complete paraplegia because of needless hesitation and delay. The risks of operation are nil. We have had no fatalities in our entire tumor series. It was only a few weeks ago that I urged

an exploratory operation on a patient with an advanced spastic paraplegia, who under the advice of a most competent neurologist was counseled not to be operated on, presumably because at no time had she experienced pain. A large extramedullary, encapsulated endothelioma was found and readily removed (Fig. 9).

#### SURGERY OF THE SPINAL ROOTS

The surgery of the spinal roots has had rather a hectic career. In 1908, section of the posterior roots for the relief of spasticity was first proposed (Förster). By so interrupting the afferent impulses, it was thought spasticity could be controlled. Sound as the physiologic basis for this operation, the results of a fairly comprehensive application in my clinic have not justified its acceptance as a reliable procedure. There are many aspects of this problem that might be discussed in the arguments pro and con. Suffice it to say now that so many roots must be cut to obtain the desired result that the question resolves itself into a rather heroic procedure, one disproportionate to the degree of improvement in locomotion and not tolerated well by the class of patients to whom it is applicable. Be it remembered, too, that the residual muscle power cannot always be forecast and the relief of spasticity does not therefore imply a return of easy locomotion. We must pronounce the operation, therefore, for the time as *sub judice*. In fact, looking on the surgery of the spinal roots from every angle, we have yet much to learn. There would seem to be an analogy between section of a spinal root central to its ganglion and section of the trigeminal root central to its ganglion, and yet I have been disappointed in some of my results when posterior root resection was performed for the relief of pain, the pain of intercostal neuralgia (Fig. 10), of postherpetic neuralgia, of brachial plexus neuralgia and of painful stump. The operation is not a new one; it was performed by Abbe in 1888. But the field is one in which there is an opportunity for investigative study as to the failure to secure the absolute relief that follows section of the root of the gasserian ganglion. Is it because there is a larger representation in cutaneous areas than we are wont to believe, or do the sympathetic fibers play a part, or, as has been suggested, are all the afferent fibers not contained within the posterior root? While the problem at first sight seems uncomplicated, I am convinced there are phases of it, anatomic and physiologic, that are not clearly understood.

#### CHORDOTOMY FOR THE RELIEF OF PAIN

In view of the unsatisfactory state of operations on the posterior roots of the cord for the relief of painful conditions, it is fortunate that a substitute measure has been found that gives greater promise

of more enduring results. In 1912, Spiller proposed for the relief of intractable pain the division of the anterolateral columns of the cord (Fig. 11). His recommendation was based on the assumption that the fibers for pain were confined to one system and that pain sensations could not be conveyed by any other. This assumption has been confirmed in his experimental laboratory and in my clinic.

I have performed the operation six times with satisfactory results in all but one. In this case the patient had suffered incessant pain for two years. After the operation, he enjoyed absolute relief for several months, when the pain returned. As the cord cannot regenerate at the site of suture, it is difficult to account for the recurrence after a period of relief. One must assume, of course, that the columns were not completely divided. The operation, as we have planned it, calls for a section of the cord, 2.5 mm. in its transverse and 2.5 mm. in its anteroposterior diameters, and recently we have overcome the

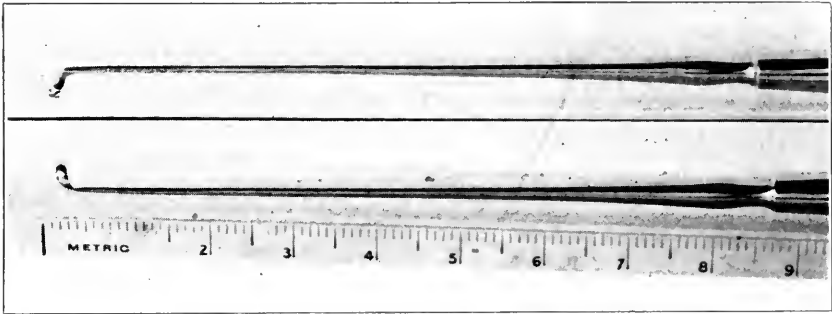


Fig. 12.—Instruments used by the author in section of the anterolateral columns of the cord. The dimensions of the mounted needle correspond exactly to the amount of cord tissue to be sectioned.

difficulty at first experienced in cutting the prescribed amount of tissue, not too much or too little, by the use of an instrument designed for this purpose (Fig. 12).

One might well ask under what conditions such an operation would be indicated: chiefly as a palliative measure to relieve the intolerable pain of malignant growths involving cord or lumbosacral plexus. Three of my cases were of this character. The other three were gunshot wounds of the spine, involving either the posterior roots or the lumbosacral plexus. I can conceive, however, of a wider application to include, possibly, aggravated forms of tabetic crisis, painful neuralgias of the thorax or lower extremities. It must be borne in mind that after this operation there is, or should be, total loss of temperature as well as pain sense. This is inevitable and must be taken into account when the operation is under considera-

tion. The operation, of course, has a limited application; but I have been so impressed with the results that I shall continue to use it as indications arise.

#### MATTERS OF TECHNIC

In recording and reviewing some of the achievements in the surgery of the nervous system, I have spoken little of matters purely technical. The mechanics of spinal or cranial surgery are easily acquired and it matters little with what tools the individual surgeon prefers to remove the laminae or section the skull. The patient should be surrounded with every safeguard. In the necessarily prolonged ordeals of cranial explorations, the administration of the anesthetic must be entrusted to an anesthetist competent and accustomed to the ways of the operator and to the operation. During the war, rather from necessity than choice, local anesthesia was employed in operations for cranial injuries, and since then some surgeons have attempted to popularize it in cranial explorations for tumors and the like; but I am not at all in sympathy with this innovation, and I believe it will prove to be only a passing fad.

The control of hemorrhage is of the utmost importance, and when feasible I transfuse every patient, as a matter of routine, after a suboccipital craniectomy and after certain other prolonged cranial explorations. It is amazing how much more rapidly the patient recovers from the immediate effects of the operation and how much shorter the convalescence. As a matter of convenience and, if necessary, of economy, we have resorted to autotransfusion. If the blood picture justifies it, we remove from 500 to 600 c.c. of blood from the patient the day before the operation. The blood is citrated and kept on ice until after the operation, when it is heated and returned to the patient.

The great problem, after all, with which the cranial surgeon is almost constantly confronted is how to deal with increased intracranial tension. Unless able to cope with this, the surgeon can never be master of the situation. Successful exploration of suprasellar lesions, of angle tumors and, in some instances even, of cortical or subcortical growths can only be safely accomplished when the tension can be reduced. This is usually possible by ventricular puncture. While as a rule the ventricles are dilated occasionally, they are collapsed, and recourse must be had to lumbar puncture, though not without attending risks.

The ventriculogram may be of service in certain exceptional circumstances in this connection. On one occasion in an exploration of the left hemisphere for tumor, the tension was so great I was afraid to reflect the dural flap until the tension was at least partially relieved,

by the withdrawal of fluid from one ventricle or the other. In each attempt, I failed to find first one, then the other, ventricle and abandoned further exploration. A week later I discovered with the ventriculogram that both ventricles were collapsed. Though cognizant of the risk, I realized that what fluid there was in the subarachnoid space would have to be removed by lumbar puncture. Accordingly, at a second sitting, 50 c.c. of fluid was withdrawn and the tension so relieved that the subsequent exploration and removal of the growth was easy of accomplishment. Originally, Dandy introduced the ventriculogram as a means of localization; but thus far it has not aided me in establishing the location of a growth not indicated by other signs.

As a means of controlling increased intracranial pressure during exploration, the intravenous use of saturated salt solution has been proposed. In the laboratory, Weed and McKibbin observed, as a result of tissue dehydration, a shrinkage in brain volume. Already one or two isolated instances have been reported<sup>1</sup> of rather startling effects. I regret it has not been of service in my hands. The method is not unattended with risk so that it is far from being regarded as a recognized or approved procedure.

#### CONCLUSION

I have touched but briefly on subjects that are now commanding attention. There have been notable achievements on the one hand and sorry failures on the other. For the coming generation, there are many fields still open for investigation, many problems still unsolved. The shortcomings and disappointments should stimulate, rather than discourage. That there is a wide enough scope for investigative pursuits to justify the recognition of neurosurgery as a specialty no one will question. Certain it is that the promise of the future lies in the hands of those who will give it their undivided attention.

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1. Sachs, Ernest, and Belcher, G. W.: Use of Saturated Salt Solution Intravenously During Intracranial Operations, *J. A. M. A.* **75**:667 (Sept. 4) 1920.

# A REVIEW OF A YEAR'S SERIES OF INTRACRANIAL TUMORS

JUNE, 1920, TO JUNE, 1921

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The object of this report is to give a survey of the 255 cases, with the presumptive diagnosis of "brain tumor," that passed through Dr. Cushing's service during my twelve months' period as his assistant. All patients referred to the hospital as possible tumor cases (suspects) have been included, even though further investigation has proved the condition to be other than tumor.

A year ago one of my predecessors, Dr. Percival Bailey, made a report<sup>1</sup> on the working classification of brain tumors then in use in the clinic. In grouping the present series, a few modifications will be made in the program which he employed. The cases will be presented under four main divisions:

1. *Verified Brain Tumors*.—In this group, the diagnosis, with the few exceptions to be noted, has been determined by the histologic examination of tissue secured at operation or necropsy.

2. *Unverified Brain Tumors*.—In these cases, though the diagnosis of brain tumor is almost certainly correct, the lesion has not as yet been disclosed and hence its histologic character remains undetermined.

3. *Brain Tumor Suspects*.—This group consists of borderline cases in which the diagnosis remains uncertain though the symptoms are strongly suggestive of tumor.

4. *Nontumor Group*.—This includes the cases referred to the hospital as tentative tumor cases, but in which, as the result of necropsy or of careful clinical study, the conditions were proved to be, or have come to be regarded as, other than tumor.

## CLASSIFICATION OF CASES

The 255 cases of the year's series are numerically apportioned in these four groups under the subdivisions shown in Table 1.

This classification differs from the one presented by Dr. Bailey in the following ways: Under Group A of "verified tumors," a subdivision (1-b) of those "verified macroscopically" has been introduced.

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1. Bailey, P.: Concerning the Clinical Classification of Intracranial Tumors, *Arch. Neurol. & Psychiat.* **5**:418-438 (April) 1921.



This is to accommodate certain tumors exposed at operation but which proved so vascular as to prohibit removal of tissue for study. Three of these tumors were obviously angiomas.

A fourth group of nontumors has been introduced in order to cover two kinds of cases: (1) certain suspected cases of tumor which were finally proved by necropsy to be conditions other than tumor; (2) cases which were referred to the clinic as possible tumor but which on careful study proved to be so obviously something else that they should not properly be regarded even as tumor "suspects." For instance, a patient with progressive muscular atrophy with bulbar palsy, although sent in with a tentative diagnosis, by a local physician, of cerebellar tumor, was without hesitation placed in the nontumor group.

TABLE 1.—GENERAL CLASSIFICATION OF CASES

<b>A. Brain Tumors Verified:</b>		
1. At operation (a) microscopically proved.....	86	
(b) macroscopically proved.....	6	
2. At necropsy (unverified at operation).....	12	
3. At necropsy (unoperated).....	3	
Total.....	107	
<b>B. Brain Tumors Unverified:</b>		
1. Evidence disclosed at operation (a) subtemporal decompression.....	15	
(b) exploration.....	31	
2. Unoperated.....	14*	
Total.....	60	
<b>C. Brain Tumor Suspects:</b>		
1. Clinically doubtful (unoperated).....	49	
2. Clinically operable (negative tumor findings).....	7	
Total.....	56	
<b>D. Nontumor Group:</b>		
1. Clinically tumor suspect (necropsy no tumor).....	6	
2. Tentative tumor diagnosis not supported.....	26	
Total.....	32	

\* Several of these are in the wards awaiting operation.

The group contains, nevertheless, a number of patients sent in as acoustic tumor suspects in the stage before choked disk or cerebellar symptoms have set in, and though they have been discarded, some of them in time may actually prove to have tumors.

Because Dr. Bailey was chiefly concerned with discussing the group of tumor suspects, which are more interesting from the standpoint purely of neurologic diagnosis, he placed this group first in his classification. This has been reversed in favor of the verified tumors, which are, after all, the more important from a therapeutic point of view.

It is not infrequent that a single case while under study, whether the patient is temporarily discharged from the hospital or not, shifts its position in the classification from one group to another. These changes may be illustrated by a case which passed step by step from Group C to Group A.

CASE 1 (Surg. No. 13783).—*A case primarily a tumor suspect (Group C); questionable thrombosis syphilitica. Subtemporal decompression; tumor unverified (Group B). Two-stage exploration; neuroblastoma verified (Group A).*—*History.*—Jan. 4, 1921, A. S., a farmer, aged 49, married, was admitted, complaining of recent weakness of the right arm and leg. The father and mother had both died of cardiovascular disease. The wife had had no miscarriages. There had been one child, who was living and well. The past history was unimportant, except for frontal headaches attributed to eye strain during the last twenty years.

*Present Illness.*—Dec. 14, 1920, three weeks before entry, the patient awakened about daybreak with a severe left frontal headache. He slept again, but on arising in the morning felt tired and bewildered. He went to work but came home at noon with a sensation of numbness of the right arm and leg. The following day he noticed that his right leg dragged somewhat.

Frontal headaches continued and were severe, and the weakness of the right arm and leg became progressive. Ten days after onset, there was a second more severe "attack of numbness of the right arm and leg," and following this the leg became so weak that the patient was confined to bed. His speech also at this time became hesitant, with some misuse of words.

*Physical Examination.*—He was well developed and nourished, of slow mentality, bewildered and mildly euphoric. Speech was somewhat incoherent, words were confused and incorrectly pronounced, and there was some apraxia. There was a hemiparesis of the right lower side of the face, arm and leg, as well as a hypesthesia of the right arm, leg and trunk. Some spasticity and a Babinski reflex were present on the right side.

*Eye:* The fundus of the right eye was pale, showing secondary atrophy with an elevation of 2 diopters. The margins of the disk were hazy and the retina showed very extensive choroiditis with numerous large patches of pigmentation. The left eye showed no choroiditis and no atrophy. There were a few linear hemorrhages, and the disk also measured 2 diopters.

Urinalysis and blood Wassermann test were negative. The roentgen ray revealed suggestive evidence of increased intracranial pressure.

The loss of power, with numbness in the right arm, leg and face, with aphasia indicating an extensive lesion of the left hemisphere, might well have been produced by thrombosis of the middle cerebral artery. The choroiditis suggested syphilis. In the hope of gaining more evidence, a lumbar puncture was made and a few c.c. of fluid, not under excessive pressure, were slowly withdrawn. It contained four cells per c.c. and no increase in globulin. A + Wassermann reaction was reported in 1 c.c. dilution. Although a positive diagnosis was not made, the symptoms and signs were sufficiently suggestive of syphilitic thrombosis, so that the patient was kept under observation and operative procedure deferred. Had the patient been discharged or transferred at this time the classification would have been "Brain tumor suspect: syphilitic thrombosis? (Group C)." He was recommended for transfer to the medical service.

*Course.*—During the next ten days his condition became progressively worse, with subnormal temperature, and pulse of about 60. Drowsiness became more marked. The degree of right hemiparesis and hemianesthesia increased. Aphasia became more pronounced, until his vocabulary was limited to "yes" and "no." Headache was severe, and he vomited on two or three occasions. The disks now measured 3 diopters. The condition, whether due to tumor or edema, evidently demanded operative relief.

*Operation.*—January 17, a left subtemporal decompression was performed. This disclosed a tight brain with flattened convolutions and without surface fluid. The ventricular tap was dry.

At this point, owing to the conditions found at operation, the diagnosis shifted the case from the suspect group to that of a probable tumor, and had he been discharged without further intervention it would have been with the diagnosis "Brain tumor: unverified (Group B)."

*Postoperative Course.*—Following the decompression he improved markedly. There was some return of strength in the right arm and leg. His vocabulary increased so that he could, to a limited extent, respond to questions. Apraxia was still evident, and when given a candle and box of matches, he looked at them blankly and could not demonstrate their use. The decompression bulged markedly.

Because of this improvement, a left osteoplastic exploration was performed, and a well-circumscribed tumor of the postcentral gyrus was disclosed. Five days later, the flap was reelevated, and the tumor, which had the gross appearance of an endothelioma, was readily enucleated. The histologic report, however, was neurocytoma (glioma group).

He made a remarkably good operative recovery and was soon able to be out of bed. Strength was gradually regained in the leg so that he walked with a little assistance. The aphasia disappeared except for hesitation over an occasional word. The apraxia cleared, and the hemianesthesia was much less in degree. The choked disks subsided, leaving only a moderate formation of new tissue.

Because of the final verification of the nature of the tumor, the case came to be placed among the verified tumors (Group A) and among those histologically identified. Had he succumbed to the first stage of the exploration and necropsy been refused, the verification would have been only macroscopic, and under Dr. Bailey's rulings would, therefore, have remained "Tumor unverified."<sup>2</sup>

Not infrequently do cases shift in this way from one group to another in the records. Undoubtedly, a good many of the unoperated

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2. It may be added that this is the chief reason for not classifying a tumor as "verified" without histologic examination, for it was my impression, owing to the circumscribed character of the tumor, its enucleability, and its attachment to the dura, that it was an endothelioma. H. C.

cases in the tumor suspect group may in time have symptoms sufficiently distinctive to justify exploration. But even an operation may sometimes fail to reveal the presence of a tumor, and tumors, indeed, may sometimes be overlooked at necropsy. The following is a striking example. The case, originally a "tumor suspect" (Group C), regarded at operation as "clinically nontumor" (Group D), proved at necropsy, made possible by a postoperative complication, to belong actually in Group A.

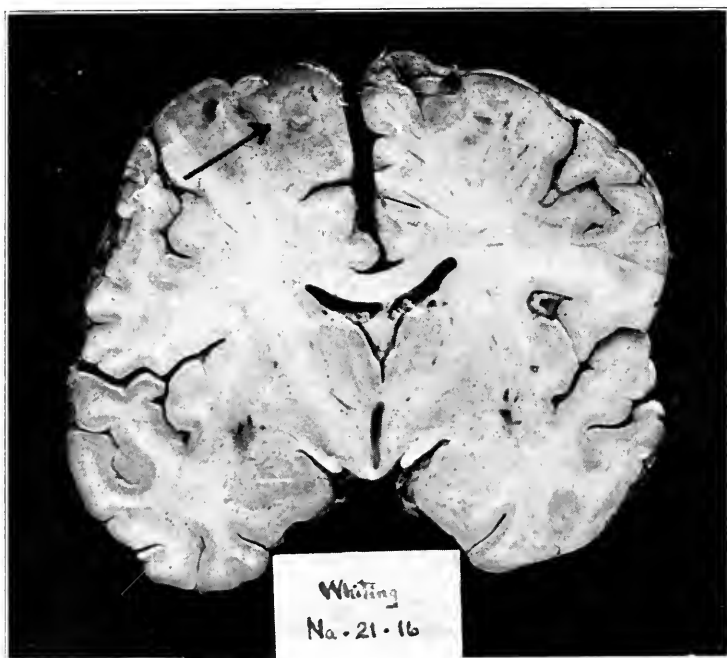


Fig. 1.—Coronal section photographed from in front. Arrow points to minute glioma in paracentral lobule.

CASE 2 (Surg. No. 14497).—Brain tumor suspect (Group C). Exploration of hemisphere negative. Operative diagnosis cerebral arteriosclerosis (Group D). Fatality. Small glioma disclosed at necropsy (Group A).—History.—Mr. C. W. W., aged 59, was admitted, May 9, 1921, with a history of recent paresthesia and progressive weakness of the left lower leg. There were no general pressure symptoms whatsoever.

*Neurologic Examination.*—This was negative except for slight loss of power associated with ankle clonus and some spasticity of the left lower leg. There were no sensory changes and no choked disks. The roentgenogram was negative. A diagnosis was made of presumptive tumor, possibly endothelioma involving the foot center.

*Operation.*—Right osteoplastic flap revealed a wet brain under no tension and some arteriovascular changes. Thorough exploration in all directions, even to the falx, showed no evidence whatsoever of tumor. The operative diagnosis was cerebral arteriosclerosis. Closure.

*Postoperative Course.*—Symptoms of the gradual formation of an extradural clot were overlooked. Consciousness was not regained. On the second day the flap was reflected and the clot was removed. The patient died eighteen hours later.

*Necropsy.*—The primary report on the brain was negative. Subsequent thin sections disclosed a small subcortical glioma, about 1.5 cm. in diameter, in the leg center of the right hemisphere (paracentral lobule).

TABLE 2.—VERIFIED TUMORS, GIVING LOCATION AND PATHOLOGIC TYPE

Location	Glioma	Gliomatous Cyst	Pituitary Adenoma	Endotheli- oma	Pharyngeal Pouch	Neurofib- roma	Carcinoma	Angioma	Tuberculoma	Cholestea- toma	Dermoid	Total
Frontal.....	2	..	..	1	..	..	..	..	..	..	..	3
Paracentral.....	6	4	..	5	..	..	2	2	..	..	..	19
Parietal.....	2	..	..	..	..	..	..	..	..	..	..	2
Supramarginal.....	3	..	..	1	..	..	..	..	..	..	..	4
Temperosphenoidal....	5	2	..	2	..	..	..	1	..	..	1	11
Occipital.....	2	1	..	..	..	..	1	..	..	..	..	4
Pituitary.....	..	..	18	..	2	..	..	..	..	..	..	20
Suprasellar.....	..	..	1	..	5	..	..	..	..	..	..	6
Cerebellar.....	6	9	..	2	..	..	..	..	2	..	..	19
Extracerebellar.....	..	..	..	..	..	9	1	..	..	..	..	10
Region fifth nerve.....	..	..	..	2	..	..	1	..	..	..	..	3
Optic chiasm.....	1	..	..	1	..	..	..	..	..	..	..	2
Pons and basal nuclei.	1	..	..	..	..	..	..	..	1	..	..	2
Lateral ventricle.....	1	..	..	..	..	..	..	..	..	..	..	1
Parietal and temporal	..	..	..	..	..	..	..	..	..	1	..	1
Total.....	29	16	19	14	7	9	5	3	3	1	1	107

These two case reports serve to show how the diagnoses, as recorded in the hospital files, may shift on subsequent reentries from one group to another until in time they come to be verified in Group A as tumor, or in Group D as nontumor.

In Table 2 the cases have been arranged roughly in accordance with the primary location and histologic diagnosis. It can be seen that the pituitary cases predominate, the intracerebellar and the para-Rolandic tumors being a close second. It is probable that tumors in other parts of the cerebrum are often overlooked.

#### THE GLIOMAS

In this short series the true brain tumors constituting the glioma group represent 42.5 per cent. of all the lesions. Tooth<sup>3</sup> in a series

3. Tooth, H.: Some Observations on the Growth and Survival Period of Intracranial Tumors, Brain **35**:61-108, 1912.

of 258 verified cases found 49.2 per cent. of gliomas. Heuer and Dandy<sup>4</sup> in a series of forty-two cases found 50 per cent. Clarke,<sup>5</sup> in ninety-nine cases, found 38.5 per cent. It is safe to say, therefore, that the gliomas represent between 40 and 50 per cent. of all intracranial tumors.

No attempt will be made to subdivide the gliomas and to distinguish neurocytomas, neuroblastomas, gliosarcomas, and so on, from the general group, for the surgical problem is the same for all and prognosis differs in no great respect. This is largely a matter for the neuropathologist, and this series is too small to draw any particular conclusions from these finer subdivisions.

From a surgical standpoint these tumors are by no means to be regarded as therapeutically hopeless, for certain of the gliomas are enucleable, and some of the gliomatous cysts when properly treated apparently are curable lesions. Dr. Cushing has pointed out<sup>6</sup> that the first two successes in his tumor series, with apparent cures lasting over thirteen years, were: (1) a solid glioma, and (2) a large gliomatous cyst, both of the cerebellum. Even a large gliomatous tumor of the infiltrating type originating in the left hemisphere may offer a surgical problem not entirely hopeless. An illustration of this is the case of a physician's wife, who had been readmitted to the clinic on several previous occasions, though she first came under my observation in 1920. Though it is now twelve years since her first symptom of tumor, she still leads a comfortable existence and is able to look after her home duties.

CASE 3 (Surg. No. 14226).—*Glioma of left hemisphere with symptoms of twelve years' duration. First pressure symptoms five years ago. Repeated partial extirpations of tumor with marked relief of symptoms and signs.*—*History.*—Mrs. A., a physician's wife, in 1909, twelve years ago, began to have convulsions. These were usually of the petit mal type, but twice were generalized, without a focal element and with immediate loss of consciousness. It was not until seven years afterward (1916) that the patient developed pressure symptoms of headache and vomiting. At this time choked disks were found.

In September, 1916, she entered the Peter Bent Brigham Hospital, and a right subtemporal decompression was performed for an "unlocalized brain tumor."

During the next few months there were frequent attacks of numbness of the right arm, associated with weakness and awkwardness of that extremity. Reflexes were exaggerated, and there were some vasomotor disturbances in

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4. Heuer, G., and Dandy, W.: A Report of Seventy Cases of Brain Tumor, *Bull. Johns Hopkins Hosp.* **27**:224-237 (Aug.) 1916.

5. Clarke, F.: A Study of the Anatomical Location and Histopathology of Ninety-Nine Brain Tumors, *Rev. neurol. & psychiat.* **14**:485-505, 1916.

6. Cushing, H.: The Special Field of Neurological Surgery: After Another Interval, *Arch. Neurol. & Psychiat.* **4**:603-637 (Dec.) 1920.

the right arm. Disks were elevated 2 diopters. An osteoplastic exploration in December, 1916, revealed a tumor about 6 cm. in diameter slightly adherent to the dura in the inferior postcentral region. The tumor, which was supposed to be an endothelioma, was removed apparently *in toto*. The histologic diagnosis, however, was glioma.

She made a perfect recovery and during the following two years she was quite normal, except for occasional attacks of numbness and jerking of the right arm, and two transient periods of aphasia lasting for less than five minutes. These symptoms, however, were comparatively slight and did not interfere at all with her social life, and she was considered entirely normal by her husband and friends. There were no more convulsions or headaches.

In 1918, the decompression area began to protrude, her right arm became weak, and there was some difficulty in writing. She was referred to Dr. W. E. Dandy in Dr. Cushing's absence abroad. He exposed the tumor again, drained

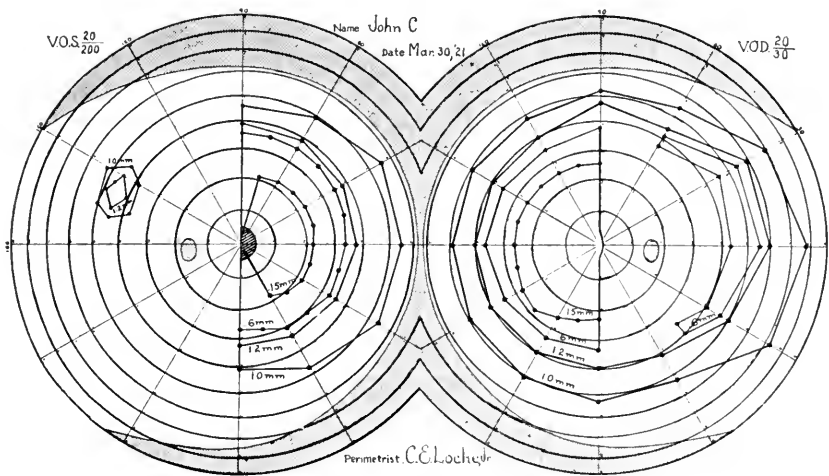


Fig. 2.—Fields of pituitary case, March 30, before operation, showing bitemporal hemianopsia in the left eye except for a small island, and in the right eye complete for smaller test objects.

a large degenerative cyst, and removed a small fragment of what appeared to be a widespread glioma, an impression confirmed by the histologic findings. She subsequently underwent a thorough course of treatment with radium. For the next two years her condition remained very good. Her right arm regained its normal strength, and she resumed her usual activities. During these two years there were very few periods of transient aphasia.

In October, 1920, she reentered the Peter Bent Brigham Hospital, owing to a recurrence of weakness of the right arm and some transient numbness both in the arm and right side of the face. There was increased intracranial pressure as evidenced by a bulging decompression and low grade of choked disk. The right arm showed weakness and slight anesthesia, some astereognosis and loss of muscle sense, as well as exaggerated deep reflexes.

The *fourth operation* conducted at this time consisted in removing a huge mass of tumor which had increased considerably in its area of distribution. It

was amazing that the procedure did not leave her completely aphasic and hemiplegic, but contrary to expectations no additional paralysis resulted and strength in the weak arm was soon partly regained. Periodic attacks in which there was slight aphasia subsequently occurred, but without loss of consciousness. She was remarkably well for another five months.

In April, 1921, because of increasing weakness of the right arm and a somewhat more pronounced aphasia, she presented herself again for study and possible operation, earnestly favored by her husband. At this time, therefore, a *fifth operation* was performed and another large mass of gliomatous tissue was scooped away. She did well, made a prompt recovery, and a recent letter tells of continued improvement since her discharge.

This illustrates, even with the least promising types of glioma, how a useful life may be prolonged for years by repeated comparatively simple operative procedures. The fact that the patient's husband is a physician and fully understands the ultimate outcome speaks well for the success of this unequal combat with a desperate disease by operative measures, several of which have been performed at his insistence under considerable protest.

#### GLIOMATOUS CYSTS

Though in the long run the infiltrating gliomas like the one mentioned above are the least amenable to surgical treatment of any of the brain tumors encountered, those gliomas which have undergone cystic degeneration are in many respects very favorable for operation and in their results often rival those following endothelioma extirpations. In this series, out of the forty-five gliomas, sixteen were classified as gliomatous cysts, as the cystic element predominated. It can be seen, furthermore, from the table, that the larger number of these were intracerebellar cysts, some of which are very favorable from a surgical standpoint.

According to this series these intracerebellar gliomas are particularly common in children. Indeed, it is interesting to note that out of the nineteen verified intracerebellar tumors fourteen, or 73 per cent., occurred in children. Also, ten of the nineteen verified tumors were cystic, and nine of these were found in children. This is in marked contrast to the series of forty-three cerebral tumors, of which only four occurred in children. Of the forty-three cerebral tumors, six were cysts, and only one occurred in a child. These figures illustrate not only the predominance of cystic gliomas in children but also their favorite anatomic location in the cerebellum.

The diagnosis of a straightforward cerebellar tumor is a comparatively simple matter when the cerebellar symptomatology is full blown. In the absence of the cardinal signs and symptoms, however, it may be most difficult to arrive at a decision. The following case may be cited in illustration.



CASE 4 (Surg. No. 14264).—*Cerebellar tumor suspect despite few cerebellar signs. Exploration; gliomatous cyst verified.*—*History.*—A school boy, aged 14, was admitted, March 20, 1921, complaining of nausea and vomiting, dizziness, and blurring of vision. In September, 1919, six months previous to entry, he began to complain of afternoon nausea. He was thought by his local physician to have chronic appendicitis. An appendectomy was performed and no pathologic condition demonstrated.

In November, 1920, he began having periodic headaches referred to the suboccipital region. During the next three months, the headache became more frequent, and there was some associated vertigo. No difficulty in gait was noted by the patient or his parents. Early in March, a few weeks previous to his admission, there was some blurring of vision with transient diplopia.

*Neurologic Examination.*—The only positive findings were: (1) slight suboccipital tenderness; (2) cracked-pot resonance of skull; (3) separation of cranial sutures and convolucional atrophy shown by the roentgen ray, and (4) choked disks of 4 diopters.

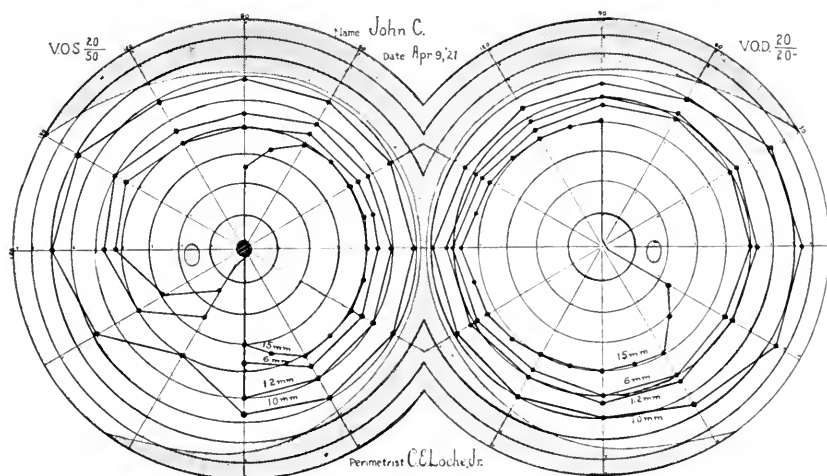


Fig. 3.—Fields on fifth day after transsphenoidal operation.

There was no nystagmus with the head in a vertical position, though when placed obliquely a few twitches occurred. Gait was very good, with no unsteadiness whatsoever. There was no definite hypermetry and no repulsion. There was a possible slight adiadokocinesia on the right, also slight hypotonia of lower extremities with diminished deep reflexes.

Although this case did not present at all a textbook picture of cerebellar tumor, it is quite representative of a fairly large group of cases. A presumptive diagnosis of cerebellar tumor (possible arachnoiditis) was made and a suboccipital exploration revealed a midline large gliomatous cyst. The points in the story that led to this diagnosis were chiefly the suboccipital headaches and tenderness and the diplopia, together with the evident internal hydrocephalus.

Comment may be made on the needless abdominal operation performed shortly before this patient's admission. It has always been the custom of the clinic to have a special paragraph in the histories of all tumor cases in which the previous diagnoses and operations are listed. It is a subject by itself and one which deserves a special report. Though abdominal operations, owing to nausea and vomiting, are not infrequent, those on the nose and throat are by far the more common, as Dr. Cushing has pointed out in some recent papers. This is possibly to be taken merely as indication of the difficulty of tumor diagnosis in the early stages of the process.

#### PITUITARY ADENOMAS AND PHARYNGEAL POUCH TUMORS

If one is to consider these two types of tumor together in the pituitary group, as is usually done, they represent, next to the gliomas,

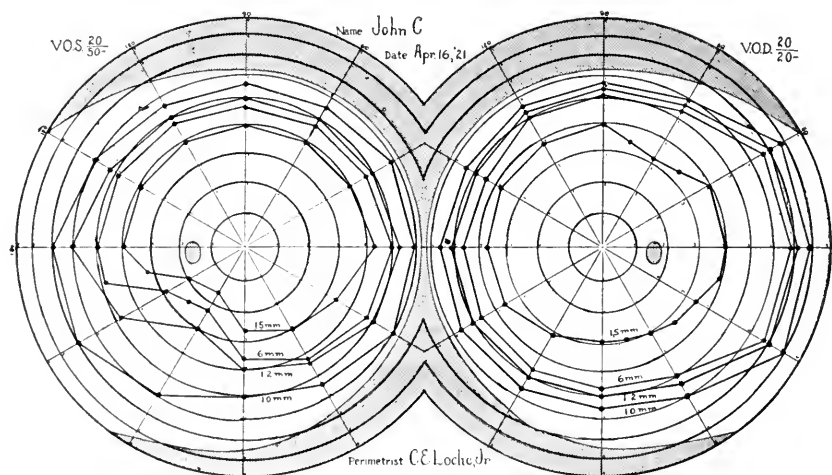


Fig. 4.—Fields on twelfth day after operation.

the largest group from the standpoint of tissue origin. In the year's series, there were twenty-six cases, nineteen of them primary adenomas of the gland and seven of them of pharyngeal pouch origin. By far the larger proportion of these lesions, therefore, were sellar rather than suprasellar, as shown in the table. There were two additional cases which gave typical pituitary signs, i. e., primary optic atrophy, bitemporal hemianopsia, low metabolism, headaches, etc., in which the lesion was also "suprasellar" but unrelated to the hypophysis. One was a glioma of the chiasm and the other a dural endothelioma of the base, both giving direct pressure on the pituitary. These I have placed in the table under optic chiasm.

The therapy of the pituitary disorders in its present stage is directed chiefly toward the preservation of vision. Indeed, loss of vision in my

brief experience is the complaint that brings most of these patients to seek surgical assistance. The usual patient with dyspituitarism disregards in large measure the general manifestations of his disorder—his neighborhood symptoms alone disturb him.

Few operations in surgery can be more gratifying to the patient or more interesting to the attendant, whose duty it is to observe the changes in the fields of vision, than one of these routine transsphenoidal procedures. That they are not unattended by some risk is shown by the results given in Table 3, two fatalities having occurred in the present series. In a few of the cases, moreover, the condition was so advanced that no great improvement in vision occurred after the operation. In the larger number of instances, however, the improvement has been rapid and sometimes astonishing. The following résumé of a case history is a good example.

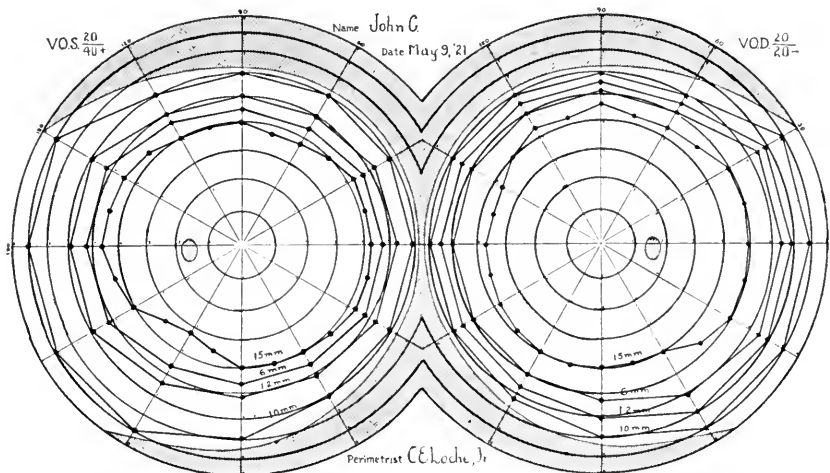


Fig. 5.—Fields one month after operation.

CASE 5 (Surg. No. 14267).—*Pituitary adenoma. Characteristic signs and symptoms. Operation. Relief.—History.*—Mr. C., a lawyer, aged 48, was admitted, March 29, 1921, complaining of loss of vision.

He had always been stout, as are several other members of his family. Between the ages of 25 and 30 he gained in weight from 150 to 190 pounds. About October, 1919, he commenced again to put on flesh, and in twelve months, his weight increased 23 pounds—from 208 to 231 pounds.

In March, 1920, about a year before his admission, he first noticed some blurring of vision, which glasses did not improve. There was gradual failure, particularly in the left eye. He had at times suffered from frontal headaches, though never severely.

Since January, 1921, five months ago, he had not been able to read even large type and he had experienced a loss of libido.

*Physical Examination.*—The patient was an obese middle-aged man, 5 feet, 6 inches in height, with normal features. The skin of the face was finely wrinkled, soft and of a sallow pallor. The comparative absence of body hirsuties was conspicuous. There was hypoplasia of the genitals. The basal metabolism was  $-10$ . The temperature and pulse were slightly subnormal.

The roentgen ray showed a widely ballooned sella turcica with absorption of its walls. There was a bilateral primary optic atrophy, with marked pallor. The perimeter disclosed a bitemporal hemianopsia (Fig. 2), complete to a 10 mm. disk on the left and to a 0.6 mm. disk on the right, though in each case an island was preserved in the temporal field. Visual acuity on the left was 20/200; on the right 20/30.

*Operation and Results.*—April 4, a transsphenoidal operation was performed. The floor of the sella was found partially destroyed and the tumor had extended into the sphenoidal cells. The capsule of the gland was split and large masses of soft struma extruded and were removed with the pituitary spoon. He made a prompt recovery with immediate subjective improvement in vision. The extent of this was revealed by his first postoperative charts taken on the fifth day (Fig. 3). He was discharged on the thirteenth day, the fields being nearly normal (Fig. 4), has resumed his professional work, and is able to read small type with ease. The fields have been taken twice subsequently (Fig. 5). The acuity in the most affected eye improved from 20/200 to 20/40 in the course of a month.

In only one of the twenty transsphenoidal procedures was the operation done for another object than preservation of vision. The exception was in the case of an acromegalic with a large sella, who suffered intensely from so-called pituitary headaches. The usual transsphenoidal operation was carried out, with removal of possibly the lower half of the soft adenoma. There was no improvement whatsoever in her complaints. It would seem that acromegalic headaches, a most baffling symptom to relieve, may be due to some other cause than sellar distention. In my experience, the other type of patient, with enlarged sella and hypopituitarism, like the case cited above, has complete relief from headaches as a result of the sellar decompression with partial tumor removal.

It would seem that the chief difficulty confronting the neurosurgeon in these cases is to distinguish between those more suitable for a transfrontal than for a transsphenoidal operation. The fact that on the operative list (Table 3) there are more transsphenoidal and transfrontal operations than there are cases shown in Table 2 indicates that several of these patients had double operations. It is sometimes very difficult to tell in the individual case which is the route to be favored. Two cases, in particular, from this series have emphasized this to me. Both of them showed the rare combination of a bitemporal hemianopsia, a greatly enlarged sella and a choked disk. It was supposed in both cases that there was an intracranial extension of a pituitary adenoma blocking the foramina of Munro. In the first case, a transfrontal operation revealed, on puncture of the ventricle, an internal hydro-

cephalus, but the enlarged gland had not ruptured through its capsule, which was bulging between the legs of the chiasm. Consequently a transsphenoidal operation was subsequently performed but with no real improvement in vision. In the second case, that of a dentist with rapidly advancing blindness, a transsphenoidal operation was the primary one; but it exposed a flattened pituitary body instead of the soft adenoma or adenomatous cyst which was expected. Subsequently, a transfrontal operation was performed, which disclosed a large pharyngeal pouch cyst which was successfully peeled out despite its partly calcareous wall. Recovery was perfect, with rapid restoration of vision practically to the normal, so that he has been able to resume his professional work, which requires good eyesight.

#### THE ENDOTHELIOMAS

There have been fourteen of these in the series. They should properly be divided into two groups: (1) those arising from the meninges with a definite dural attachment, the more common type, of which there were twelve in the series, and (2) those of supposed pial origin. There were two of the latter, both exceedingly vascular tumors in the posterior fossa, disclosed by a suboccipital operation. Both of them, moreover, were in children, and though the tumors were exposed and have an unmistakable appearance, they were not histologically verified, and have therefore been placed in my Group A, 1-b.

The other and more common endotheliomas are in one sense the most favorable, from a therapeutic point of view, of all tumors, owing to their enucleability when accessible. When, however, they do not primarily involve an area of the cortex, irritation of which gives early evidence of their presence, they may be exceedingly difficult to diagnose and consequently may attain a large size which renders their removal extremely difficult and hazardous. Because of their comparatively slow rate of growth and the lack of reaction in the surrounding tissue, they often fail to produce either a choked disk or other evidences of increased intracranial pressure until late in their development, and the growth may reach almost the size of a baseball before symptoms come to light.

Their presence at times may be revealed by the roentgen ray, owing to the tendency of the overlying bone to become hypertrophied and thickened. This hyperostosis which is due to invasion of the bone by tumor may involve the inner surface of the adjacent cranium or may lead to a great thickening of the bone throughout. Under these circumstances, the diagnosis is readily made, but otherwise it may be difficult in the extreme. The tumors have definite seats of predilection which must be borne in mind when making a diagnosis. As shown by the table, five were paracentral, two were temporosphenoidal, arising from the

meninges of the middle fossa, two arose primarily from the gasserian meninges, if one may judge from the primary symptoms, another was frontal, still another a supramarginal case<sup>7</sup> with global aphasia, and the last was an inoperable tumor overlying the pituitary fossa. These tumors provoke a characteristic reaction in the adjacent blood vessels, and although they themselves are not particularly vascular, the adjoining meningeal vessels and those of the diploe and scalp vessels become greatly enlarged. Indeed, mere palpation of the head sometimes reveals localized pulsation in the vessels of the scalp over the tumor. The meningeal vessels deeply groove the inner table, giving a characteristic appearance easily recognized by the roentgen ray. In consequence of this, operations on these tumors are attended by particular hazards not only from immediate loss of blood but from the likelihood of continued postoperative oozing from the denuded bone flap after its closure. One of these patients died, presumably from hemorrhage. The patient was a feeble young girl with marked pressure symptoms. The tumor was unexpectedly laid bare during an exploration for an "unlocalizable" growth. There was marked bleeding from the bone, and she did not survive for a second-stage procedure (Compare with Case 9 in the list of fatalities).

#### THE ACOUSTIC TUMORS

These tumors are in number next to the endotheliomas in the series, there having been nine under observation during the year. The particular description of this type of tumor has been covered in Dr. Cushing's monograph on the subject. In the stage in which they usually appear in the clinic, the diagnosis is possibly capable of greater exactitude than in any other form of tumor. Not only the precise location but the histologic character of the lesion can be foretold.

The chief difficulties lie in the attempt to make a diagnosis sufficiently early to permit of a total enucleation. For by the time general pressure symptoms are pronounced and the syndrome of the cerebello-pontile angle is full blown, the growth has so deformed the brain stem that attempts to remove it in its entirety have heretofore been disastrous. It has been the chief aim in this clinic to reduce the mortality of these procedures, which up to recent times have ranged from 60 per cent. upward. With this object, a less extensive procedure than an attempted total removal is carried out, namely, what is called an intracapsular enucleation.

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7. Bremer, F.: Global Aphasia and Bilateral Apraxia Due to an Endothelioma Compressing the Gyrus Supramarginalis, *Arch. Neurol. & Psychiat.* **5**:663-669 (June) 1921.

There are certain cases in which this is not difficult, namely, those in which the tumor cells have undergone fatty degeneration, for under these circumstances the contents of the capsule may be scooped out, leaving little behind but the collapsed shell. When the tumor, however, is dense, fibrous and vascular, this procedure is impracticable, and little can be gained beyond the effect of the decompression.

It has been stated that several of the cases in the group of brain tumor suspects have been of patients sent in under the suspicion of having primary acoustic tumors, and though the auditory signs are sufficiently characteristic of possible primary involvement of the nerve from tumor, we are still somewhat hesitant in operating in such cases until the existence of a small tumor can be assured with more definiteness. It is to be hoped that the time will come when the distressing consequences of a fully developed acoustic tumor can be forestalled. Until then it would be foolhardy to take undue risks or to carry out an unnecessary exploration for a presumed growth which is giving no symptoms beyond partial deafness and may continue in this stage for many years.

Even in the advanced stage of the malady, in which at present the operations are usually conducted, Dr. Cushing confesses to giving way occasionally to the temptation of undertaking a more radical procedure than he has advocated in print. In one of the cases in my series (Case 8 in the series of fatalities), a very favorable one, after thorough enucleation of the tumor contents, the attempt to remove the largely detached capsule and thus complete the enucleation was irresistible. This caused some bleeding in the angle with resultant contusion of the brain stem while controlling it and an early fatality.

#### TUMORS OF VARIED HISTOLOGY

The remaining thirteen cases in this series represent far less common types of tumor, some of them so rare that they might not be represented in a group of tumor cases of a far greater number.

*Carcinoma.*—There were five cases so listed. Three of them were recognized as metastatic and the patients were not operated on, verification being possible at necropsy. In one, the lesion was located in the cerebellopontile angle with a symptomatology resembling that of an acoustic neuroma except for its very rapid course. Another was a rare example of adenocarcinoma of the pituitary invading the meninges of the middle fossa and giving trigeminal symptoms which led to a clinical diagnosis of endothelioma of the trigeminal sheath. Not until examination of the tissues removed at operation was the true nature of the lesion disclosed. This patient has made temporarily a good recovery.

*Angioma.*—There have been three of these rare lesions in the series, and there are not more than six in Dr. Cushing's entire list of nearly 700 verified tumors. In only one of the cases were there any pressure symptoms, that of a small child with a huge diffuse pulsating tangle of vessels of the temporal region. In the other two cases, the only symptoms were of focal epilepsy of recent origin. Both were young adults. In both of them an osteoplastic resection revealed a fairly circumscribed tangle of huge thin-walled vessels the size of a lead pencil, occupying an area about 5 cm. in diameter. In the first case, nothing was done except to ligate a single trunk and to leave subsequently an overlying cranial defect through which the area was radiated. In the second case, a more radical procedure was attempted which nearly led to a fatality from loss of blood. No tissue could be secured in either case, and I have therefore listed these lesions as verified only macroscopically in Group A.

*Tuberculoma.*—Of the three cases in the series, the lesion in two was in the cerebellum. Both patients survive, but the experience of the clinic gives a very bad prognosis after removal even of an unruptured tubercle. Six months, I believe, has been the longest survival period, though cases have been reported from other clinics of longer survival and perhaps even of cure. In the single postoperative fatality (Case 19), a tuberculoma of the brain stem was disclosed at necropsy. The diagnosis otherwise would not have been verified, for the presence of a supposed right astereognosis led to an exploration of the left hemisphere.

*Cholesteatoma.*—This was possibly the most remarkable case in the series. It will be reported elsewhere. The tumor, which had produced no symptoms except thinning of the skull, was a huge growth almost displacing the entire hemisphere. It was removed intact by an osteoplastic cranial resection. It had no connection with the ear.

*Dermoid.*—Still more rare, though a tumor in the same category as the above, was a dermoid tumor the size of a golf ball removed from the tip of the temporal lobe. The patient, a young army officer, had had tuberculous glands of the neck and naturally was under the suspicion of having an intracranial tubercle. Both of these patients made perfect recoveries.

#### THE OPERATIVE PROCEDURES

In Table 3 I have attempted, in as simple terms as possible, to indicate the number of operative procedures and to couple them with the fatalities, early and late. It is a difficult matter to present, and I am not entirely satisfied with the table, which does not correspond with my general impression of the results. Of the ninety-five operations which resulted in tumor exposure, with partial or total enucleation, there were only eight fatalities, whereas there were twelve fatalities



resulting from the eighty-five operations in which the tumor was not exposed. My impression had been, until these figures were assembled, that the risks were greatly increased by the attempt at enucleation.

The fifty-four lateral osteoplastic flap operations of varying types represent the larger number. Sometimes these operations are conducted with an immediate subtemporal decompression when tension is marked, and even though no tumor is disclosed the flap is replaced. If the operator, however, has been led to open the dura widely, and no tumor, or a tumor obviously not enucleable, has been exposed, it may be necessary, owing to the protrusion, to peel off the reflected bone and close the scalp alone. Though every effort is made, particularly in cases which have a favorable ultimate prognosis, to preserve an intact cranium, it was necessary for the reasons given to sacrifice the bone in eight of the fifty-four operations. These, however, have usually been unfavorable cases.

TABLE 3.—BRAIN TUMOR OPERATIONS AND FATALITIES

Operation	Complete or Partial Tumor Extirpation			Exploration or Decompression Alone			Total Operations	Total Fatalities
	Number	Early Fatality	Subsequent Fatality	Number	Early Fatality	Subsequent Fatality		
Lateral osteoplastic exposure....	32	0	1	22	2	3	54	5
Suboccipital exposure.....	20	0	1	28	3	0	48	4
Transsphenoidal pituitary.....	23	0	2	0	0	0	23	2
Osteoplastic frontal pituitary....	8	0	2	2	0	0	10	2
Local craniectomy.....	12	2	0	1	0	0	13	2
Subtemporal decompression.....	0	0	0	32	2	2	32	4
Total.....	95	2	6	85	7	5	180	20

The ten transfrontal explorations for suprasellar lesions, though also osteoplastic, have been separately listed, as they represent a special type of procedure.

Of the forty-eight cerebellar operations, seven were performed for cerebellopontile angle tumors, and forty-one for tumors of the cerebellum. In twenty-three of these operations tumors were exposed, in ten a chronic arachnoiditis was disclosed as the possible source of the supposed tumor symptoms, and in fifteen no lesion but great tension was found. Of the twenty-three cerebellar tumors brought into view, nine were gliomatous cysts. This, as I have stated, is considered a very favorable sort of lesion for surgical treatment and has an excellent prognosis.

Comment has already been made on the transsphenoidal operations and the basis on which they are conducted. The first twenty-one cases in the series were carried out without accident. The last two led to fatality. In one of them (Case 24 of the following list) the operation

was misjudged. The case was suited for a transfrontal operation, it being a pharyngeal pouch tumor which lay in a distended sella and thereby led to a presumptive diagnosis of pituitary adenoma. In the other case (Case 18 of the fatalities), though one favorable for a transsphenoidal procedure, the patient succumbed from meningitis on the sixteenth day. This gives an operative mortality for the twenty-three transsphenoidal procedures of 8.7 per cent. Of the transfrontal operations there were two fatalities in the ten operations, or 20 per cent. mortality; but as those procedures are carried out for totally different lesions, this comparison of mortality figures means nothing favorable or unfavorable to the route in question, even were the series larger.

The subtemporal decompression of course is employed usually as a temporizing measure in cases with pressure signs either to gain time or when the lesion is not susceptible of localization. In this way, vision may be preserved while the surgeon is awaiting localizing signs. In two of the thirty-two decompressions performed for this purpose, the tumor was unexpectedly exposed in the temporal lobe. There were four fatalities, three of the operations having been permitted by Dr. Cushing in practically moribund patients. I had performed a decompression in one case of like nature which seemed hopeless, yet the patient survived and subsequently had a successful tumor removal.

There were thirteen operations which have been grouped under craniectomy. These consisted of exploration through an opening similar to an enlarged ganglion exposure or through a defect made in an old osteoplastic flap.

There follows a list of the fatal cases.

#### NOTES ON FATAL CASES

CASE 6 (Surg. No. 15429).—A man, aged 24, presented symptoms of a posterior lesion. A ventricle tap was performed which yielded bloody fluid. Cerebellar exploration was negative. The patient died four hours after operation. Necropsy revealed a glioma filling the lateral ventricles.

CASE 7 (Surg. No. 13613).—A man, aged 27, presented symptoms of a posterior lesion and complete blindness. There was accidental trauma of the brain during perforation of the skull (paper thin). Cerebellar exploration was negative. The patient died ten hours after operation. Necropsy revealed an enormous subcortical glioma occupying about two thirds of the cerebral hemisphere.

CASE 8 (Surg. No. 14229).—A man, aged 49, had typical symptoms and signs of acoustic tumor. Cerebellar exploration and thorough enucleation of a large right acoustic tumor were performed. This resulted in shock and death nine hours after operation. Necropsy revealed a blood clot at the cerebellopontile angle.

CASE 9 (Surg. No. 14387).—A girl, aged 12, presented symptoms and signs of a subcortical tumor of the right hemisphere. Osteoplastic flap exploration revealed apparently endothelioma, with overlying bony changes. The procedure was associated with considerable hemorrhage. Enucleation was not attempted. Shock resulted and transfusion was performed. Death ensued one hour after operation. Necropsy revealed a very large endothelioma of the right hemisphere.

CASE 10 (Surg. No. 13028).—A man, aged 38, entered the ward in a moribund condition. There were few localizing signs, and a questionable left-sided hypesthesia. A right subtemporal decompression was performed. Reaction was poor. Bronchopneumonia developed and the patient died thirty hours after operation. Necropsy revealed a right temporal lobe glioma.

CASE 11 (Surg. No. 13340).—A boy, aged 14, presented neighborhood and glandular pituitary symptoms and very little change in sella. A transfrontal operation disclosed tumor of the chiasm. Postoperative hyperthermia developed and the patient died thirty-six hours later. Necropsy revealed glioma of the optic chiasm.

CASE 12 (Surg. No. 12540).—A woman, aged 60, had a lesion localized in the region of the left fifth nerve. Exploration revealed a widespreading tumor about the gasserian ganglion. Partial extirpation was performed; an attempt at more complete enucleation resulted in a tear of the cavernous sinus. Transfusion was performed. Death ensued four hours after operation. Necropsy revealed widespreading dural endothelioma of basal meninges from chiasm to medulla.

CASE 13 (Surg. No. 14222).—A boy, aged 14, presented a typical picture of intracerebellar tumor. Exploration (Horrax) disclosed a cystic glioma of the right hemisphere. Drainage of the cyst and removal of a fragment of wall were performed. Twenty-one days later the patient died. Necropsy revealed a very extensive glioma of the right and left hemispheres and vermis, partially cystic.

CASE 14 (Surg. No. 12610).—A woman, aged 52, for nineteen years had had jacksonian attacks of the right leg and a clear-cut clinical picture of a parasagittal endothelioma. Osteoplastic flap exploration disclosed a large parasagittal endothelioma. The bulk of the tumor was removed. Consciousness was not regained, and the patient died seven days after operation.

CASE 15 (Surg. No. 13886).—A man, aged 54, had suffered gradual mental impairment, associated with headaches, loss of vision, incontinence, drowsiness and untidiness. Examination revealed choked disks. A right osteoplastic frontal exploration, two stages, disclosed no tumor. Bronchopneumonia developed. The patient died twenty-nine days after operation. Necropsy revealed a huge endothelioma arising from the ethmoid region and separating the frontal lobes.

CASE 16 (Surg. No. 12581).—A woman, aged 31, presented a hypopituitary symptomatology—an extreme degree of exophthalmos, bilateral primary optic atrophy, and a history indicating increased intracranial pressure. A subtemporal decompression was performed; a very tight brain was encountered but no lesion, and the wound was closed. She rapidly went down hill. Bronchopneumonia developed and she died nineteen days after the operation. Necropsy was not performed.

CASE 17 (Surg. No. 14327).—A woman, aged 45, gave a long history of pituitary disorder—primary atrophy, destroyed sella, bitemporal hemianopsia, mental impairment and untidiness. A transfrontal osteoplastic flap operation

disclosed a large suprasellar cyst. There was drainage of chocolate colored contents. The cyst was largely excised and the wound closed. Postoperative hyperthermia and drowsiness developed and the patient died nine days later during a wave of hyperthermia, with a temperature of 107 F. Necropsy revealed remnants of a very large suprasellar tumor.

CASE 18 (Surg. No. 14323).—A man, aged 40, gave a typical pituitary history, with gain of weight, loss of vision and impotence. Examination revealed temporal hemianopsia, right eye; blindness, left eye; bilateral primary optic atrophy, etc. A transsphenoidal operation was performed. There was marked visual improvement, the blind eye returning to 20/50 acuity. The twelfth day after operation he had a chill, headache and rigidity of the neck. He died sixteen days after operation. Necropsy revealed basilar purulent meningitis; remnants of intrasellar tumor.

CASE 19 (Surg. No. 13426).—A boy, aged 8, presented a Weber's syndrome, pressure signs and questionable asteriognosis. Osteoplastic flap exploration was negative. A large internal hydrocephalus was found. Decompression was performed and the wound closed. The patient died twenty-two hours after operation. Necropsy revealed tuberculoma of the thalamus and pons, left.

CASE 20 (Surg. No. 13389).—A man, aged 54, entered the ward in comatose condition. There was a history of left hemiplegia and choked disks. A right subtemporal decompression was performed, resulting in an unexpected disclosure of a deep gliomatous cyst. The wound was closed. Postoperative hyperthermia developed. There was no return of consciousness. Bronchopneumonia developed, and the patient died three days after operation. No necropsy was performed.

CASE 21 (Surg. No. 14311).—A woman, aged 54, entered the ward in a comatose condition. There was a history of loss of orientation and hallucinations and choked disks. Subtemporal decompression, without anesthesia, showed a tense brain. The wound was closed and the patient died twelve hours later. Necropsy revealed a large right subcortical frontal glioma.

CASE 22 (Surg. No. 14497).—This case of small glioma is reported as Case 2 in the body of the article.

CASE 23 (Surg. No. 14037).—A woman, aged 50, gave a history of numbness of the right arm, headache, vomiting and amnesia. A right subtemporal decompression was performed. Eleven days after operation, marked stupor developed and soon Cheyne-Stokes' respirations. The patient died fourteen days after operation. Necropsy revealed ependymal glioma, metastatic, of the left superior parietal region and marked edema of the brain about it.

CASE 24 (Surg. No. 14011).—A boy, aged 11, presented the usual symptoms and signs of pituitary tumor. Transsphenoidal exploration disclosed a cyst which was drained. Following the operation there was a persistent leak of cerebrospinal fluid. The fourth day after operation he developed headache, high temperature and rigidity of the neck. He died the eighth day following operation. Necropsy revealed purulent basilar meningitis and a pharyngeal pouch tumor.

CASE 25 (Surg. No. 13951).—A boy, aged 17, had right hemiplegia and right homonymous hemianopsia and choked disks. A preliminary decompression was performed. An osteoplastic flap revealed negative findings. There was rapid loss of strength. He died fourteen days after operation, bronchopneumonia having developed. Necropsy revealed a large subcortical left temporoparietal glioma.

## CONCLUSION

In closing this report I am aware that a year's experience with such a complicated subject as the surgery of brain tumors represents but a beginning. Moreover, the end-results of this series of operations are more important than the immediate results seen only during the course of twelve months. I wish to express my great obligation to Dr. Cushing for allowing me to present this brief review of the cases, in his service, which have come under my care.

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## POSTOPERATIVE BILIARY FISTULAS

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Biliary fistulas are of great surgical interest because of their manifold causes, the variety of their communications, and the important problems connected with their surgical management. Two types occur, spontaneous and postoperative.

Spontaneous biliary fistulas are surgical curiosities because of the bizarre course which they may pursue. In finding an exit externally they may open at various points in the chest or abdominal wall, or even in the right thigh, but they usually open at or near the umbilicus, probably being directed to this point by the falciform ligament. Spontaneous fistulas may communicate internally with almost any part of the gastro-intestinal tract, a bronchus, the right kidney or the urinary bladder; they may even perforate the pericardium. The rarity of spontaneous biliary fistulas and their curious communications constitute their distinguishing features; they are not included in the series on which this paper is based.

A postoperative biliary fistula which continues beyond the expected time limit, after an apparently successful operation on the gallbladder or ducts, is not only an annoyance to the patient, but is most disconcerting to the surgeon. Failure of the fistula to close spontaneously means that some obstruction prevents the bile from flowing in its normal course; that faulty surgery is probably responsible for the disturbing sequel, and that repair of the fistula may offer serious difficulties. Nor is the situation any less confusing for the surgeon called on to repair a fistula following an operation by another surgeon, for, although spared any responsibility for the fistula, perplexing factors have been added because of insufficient knowledge concerning the findings and details of the original and subsequent operations.

### CAUSES OF POSTOPERATIVE BILIARY FISTULAS

A recent review of the 166 cases of biliary fistulas seen in the Mayo Clinic between Jan. 1, 1910, and Dec. 31, 1919, suggested the publication of the series as a basis for some observations on their causes and surgical management. That gallstones and their complications are primarily the cause of postoperative fistulas in a large percentage of cases, is

a fact most apparent in this review (Table 1). The findings at operation, together with the historical data, show that in 85 per cent. of the cases gallstones were directly or indirectly the causative factor. If one includes also the cases in which the original operations were carried out on the assumption that gallstones were present, although stones were not found at operation, the symptoms being due to cholecystitis, there remain only a very few cases in which the symptoms of gallstones did not play a primary part (Table 2).

TABLE 1.—BILIARY FISTULAS

Proved Cause of Fistula	Cases	Gallstones Found at First Operation	Gall-bladder Not Previously Removed	Gall-bladder Previously Removed	Average Duration of Fistula	Maximum Duration of Fistula	Minimum Duration of Fistula
Stone in the common duct.....	41	26	41	0	12.4 mos.	4 yrs.	1 mo.
Stone in the cystic duct.....	35	25	35	0	24.5 mos.	9 yrs.	0.75 mo.
Stone in the gall-bladder.....	28	14	28	0	37 mos.	11 yrs.	3 mos.
Stone in the hepatic duct.....	1	1	1	0	.....	11 mos.	
Recurrent cholecystitis in residual gall-bladder.....	22	12	22	0	10 mos.	3.5 yrs.	2.2 mos.
Division of the common duct.....	13	8	3	10	10.8 mos.	5 yrs.	1 mo.
Stricture of the common or hepatic duct.....	8						
Stricture of the cystic duct.....	3						
Cancer of the gall-bladder.....	2	1	2	0	9 mos.	1 yr.	6 mos.
Cancer of the pancreas.....	4	2	3	1	4.5 mos.	7 mos.	2.5 mos.
Chronic pancreatitis.....	4	1	4	0	5 mos.	9 mos.	2.75 mos.
"Cirrhosis of the liver".....	1						
Hepatitis and infected hematoma.....	1	0	3	0	.....	9 yrs.	1 mo.
"Prolonged tube drainage".....	1						
Indeterminate.....	2	1	0	2	3.5 mos.	5 mos.	2 mos.

TABLE 2.—CASES IN WHICH STONES WERE NOT FOUND, BUT MAY HAVE BEEN PRESENT AT ORIGINAL OR SUBSEQUENT OPERATIONS

Cases.....	26 (15.7 per cent.)
Stricture of the common or hepatic duct.....	2
Division of the common duct.....	5
Recurring cholecystitis.....	10
Chronic pancreatitis.....	3
Carcinoma of the pancreas.....	2
Carcinoma of the gallbladder.....	1
Cirrhosis of the liver.....	1
Hepatitis.....	1
Indeterminate.....	1

Another obvious fact is that the gallbladder had been removed in only 10 per cent. of the patients with chronic fistulas. The relative merits of cholecystectomy and cholecystostomy are now generally recognized, and the facts brought out in this series of cases emphasize

these relative merits. It is reasonable to assume that by removal of the gallbladder at the first operation a large proportion of these fistulas could have been prevented. Cholecystectomy would have precluded a persisting fistula in the twenty-two cases of chronic cholecystitis; it would have eliminated the group of twenty-eight cases of "stones in the gallbladder," and it would have made the oversight of a stone in the cystic duct very unlikely. Moreover, a stone in the common duct is much more likely to be discovered by the surgeon who performs a cholecystectomy than by the surgeon who contents himself with a cholecystostomy. In cholecystostomy, more risk of an incomplete operation or of overlooking a pathologic condition is involved than in cholecystectomy. To the latter operation is added the further danger of trauma to the hepatic or common ducts, although in a well conducted operation this danger is negligible.

Another point to be noted is that, considering the technical and anatomic difficulties often associated with secondary operations on the biliary tract, the group of cases in which the condition actually producing the fistula is listed as "undetermined" is remarkably small. The surgeon may wisely leave the condition undetermined if he finds that biliary function can be satisfactorily and permanently reestablished without a prolonged investigation which might involve additional risk and serve no good purpose.

#### PREVENTION OF A BILIARY FISTULA

More important than the variety of conditions which produce fistulas is the question whether or not such a result could have been prevented at the original operation. Because of the margin of error always present in surgery of the gallbladder and ducts, the numerous and varied factors which contribute to an inadequate original operation, and the unknown incidence of stone reformation, it is doubtful whether total elimination of postoperative fistulas can be attained. Taking all circumstances into consideration, however, and excluding malignancy and those cases in which a fistula is deliberately provided for, it would seem that the unanticipated occurrence of a postoperative fistula should be an exceedingly rare sequel to any operation on the biliary tract. The incidence of such fistulas in the Mayo Clinic from 1910 to 1919, inclusive, was 0.1 per cent., twelve in 9,009 operations on the gallbladder and ducts. Four of these twelve persistent fistulas, as shown by subsequent operation, were due to stone in the common duct, four to stone in the cystic duct, three to recurrent cholecystitis in a residual gallbladder, and one to stricture of the common duct following cholecystectomy. The most interesting fact concerning this group of twelve



cases is that, with one exception, the last case mentioned, in no instance had the gallbladder been removed. A series of 5,997 cholecystectomies in the last fourteen years in the Mayo Clinic with but one subsequent fistula, compared with a series of 1,879 cholecystostomies with eleven postoperative fistulas, is a striking illustration of one advantage of cholecystectomy. Cholecystectomy not only invites more thorough exploration, but eradicates more efficiently potential and actual pathologic processes.

#### FACTORS IN THE PRODUCTION OF POSTOPERATIVE FISTULAS

Causes which lead to overlooking or producing conditions found to be diverting the bile through the fistula may profitably be considered. Surgical inexperience, inadequate exposure, an operation of intrinsic difficulty, a hurried operation, incomplete or careless exploration, failure to remove the gallbladder, accidental injuries to the ducts, and unintelligent use of drainage, are the most apparent indirect causes, and are deserving of some individual comment.

*Inexperience.*—In surgery of the gallbladder and ducts, inexperience takes a greater toll than in many other surgical fields. First, faulty diagnosis may lead to ill-advised operation for cancer of the pancreas. Second, inexperience is responsible for failure to realize the significance of findings at operation, such, for example, as that clear colorless fluid in the gallbladder (so-called white bile) means obstruction of the cystic duct or complete obstruction of the common duct; or that, even if a stone cannot be palpated, a dilated common duct is an indication for incision and exploration, especially if there is an associated history of jaundice. Third, the inability of the inexperienced operator to carry out safely such surgical measures as the removal of a soft stone from the ampulla of Vater or stones from the hepatic duct renders it difficult for him to accomplish desired results. Finally, if operative injuries, particularly of the ducts, are to be avoided, experience is essential.

Inexperience is a relative term, for, in all the problems of diagnosis and treatment which can arise in diseases of the gallbladder and ducts, it is impossible for any surgeon to become so efficient that further experience would not at times be beneficial to the patient. The results of gross inexperience, however, will probably be much less in evidence when medical graduates will be required to obtain the necessary post-graduate study before invading special surgical fields, and when hospital standardization reaches the plane on which it should rest. In the meantime, the patient who places himself in the hands of the inexperienced surgeon is fortunate if that surgeon realizes his limitations and does not attempt more advanced surgery than these allow.

*Inadequate Exposure.*—The master word in the craft of surgery is simplicity (Moynihan). One of the most common mistakes made by surgeons is the failure to appreciate the importance of good exposure in contributing to the simplicity in operation. How frequently may be recalled operations made unnecessarily difficult by a small incision, poor light, and an obscured operative field. Nearly all the serious situations in operations on the thyroid, spleen, kidney, pelvic organs, and so forth, are associated with difficult accessibility. In surgery of the gallbladder, accessibility is sometimes particularly difficult, and the same operative procedure may entail the widest limit of difficulty or facility.

Disastrous sequelae may be directly attributable to inadequate exposure, and we may appropriately refer briefly to the more important means of securing the best possible exposure. A suitably placed incision of sufficient length is essential. In the clinic, we have adopted a modified Bevan incision in the rectus, beginning high in the epigastrium and about 1.25 cm. to the right of the middle line; such an incision gives the most adequate access to any lesion that may be encountered in the gallbladder or ducts. The incision in the skin and subcutaneous tissues should sufficiently exceed in length the proposed opening in the aponeurosis, muscle and peritoneum, so that, should enlargement of the opening in these deeper layers become necessary as the operation proceeds, it would not be necessary to extend the incision in the skin or subcutaneous tissues. A capable first assistant can be of great service in drawing away from the field of operation the hepatic flexure of the colon, the duodenum, and the pyloric end of the stomach. Masson<sup>1</sup> has recently suggested a most useful means of gaining better view and access. He introduces a large gauze pack between the superior and outer aspects of the right lobe of the liver and the diaphragm, so as to swing and rotate the liver downward and forward, gaining in this way not only better access to the gallbladder and ducts, but lessening the excursions of the liver during respiration.

*An Operation of Intrinsic Difficulty.*—Even with every aid, the difficulties inherent in the individual operation may be considerable because of a fleshy patient, a high-lying liver, inflammatory thickening of the gallbladder, ducts, and pancreas, or adhesions which prohibit a satisfactory exposure. Moynihan has recently stated that he knows of nothing in surgery which approaches in difficulty a cholecystectomy under such circumstances. The conditions may be sufficient to leave doubt in the surgeon's mind as to whether the full extent of the pathologic processes have been determined and dealt with; usually, however,

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1. Masson, J. C.: Exposure in Gallbladder Surgery, *Ann. Surg.* **69**:422-424 (April) 1919.

the subsequent course of the patient shows this fear to be unfounded. There are cases in which failure to deal with the conditions which later are responsible for the continued draining of bile can be fairly attributed to anatomic and pathologic obstacles, and a persisting fistula may also follow an unusually difficult operation on the deep ducts, such as resection for cancer, cyst, or stricture, or a reconstructive operation for existing fistula.

*Hurried Operations.*—It is hardly necessary to comment on the dangers of a hurried operation. Speed is responsible for many mistakes in abdominal surgery. What appears to a brilliantly executed operation may in reality be quite incomplete through overlooking additional lesions. When operations on the gallbladder are followed by unfortunate sequelae and discreditable results, it is usually because they have been carried out on insufficient indications or because important details have been sacrificed to haste.

*Incomplete or Careless Exploration.*—A thorough exploration is one of the most important principles in abdominal surgery, and in the abdomen no region demands so much care and efficiency in exploration as does the biliary tract. Every means, inspection, palpation, and instrumentation, should be utilized. If, for example, small nodules are palpated in the line of the cystic duct, and a differentiation of glands and calculi cannot be established with certainty by inspection and palpation, exploration should be continued by splitting the gallbladder down to the opening of the cystic duct, so that by instrumentation it can be determined whether the palpable nodules are within or without the duct. Similarly, when doubt exists concerning the patency of the common or hepatic ducts (occasionally careful inspection and palpation of ducts fails to convince even the most skilled surgeon that the ducts are clear), incision of the main duct and exploration with probe and scoops are imperative. The marked similarity under palpation between cancer of the duct and stone should not be forgotten. Exploration of the pancreas involves difficulties in the differentiation of various degrees of pancreatitis, of the nodular form of pancreatitis, and of cancer. In such cases, particularly if obstructive jaundice exists, a correct differentiation is extremely important, both from the standpoint of operative procedure and from that of prognosis. Fortunately, such differentiation can usually be made at operation.

Uncertainties may remain after most efficient exploration; on the other hand, a most obvious pathologic condition is sometimes overlooked by neglect or carelessness in exploring. Such oversight is doubtless partly due to the assumption that a gallbladder filled with stones is sufficient and satisfactory evidence to support the history, and that the removal of the stones should assure the patient complete relief. A

diligent, routine search for surgical conditions in other portions of the biliary tract is accordingly omitted, frequently to the continued and later disability of the patient. An incomplete operation may thus be, and usually is, the primary cause for a persistent fistula, the most common mistake being failure to remove all the stones from the cystic, common, or hepatic ducts. In this series there were 105 such cases. Rare conditions, such as a ruptured gallbladder with localized abscess and beginning peritonitis, occasionally justify incomplete operation in anticipation of dealing radically with the pathologic process at a later and safer time.

*Failure to Remove the Gallbladder.*—A contributory factor to post-operative fistula in 90 per cent. of the cases in this series was failure to remove the gallbladder at the first operation; doubtless the removal would have spared these patients the second operation. Comparative statistics of experienced surgeons show that cholecystectomy has a decided superiority over cholecystostomy in every respect, operative mortality, immediate and late results, and biliary function.

*Accidental Injury to Ducts.*—Under this heading may be included the most serious conditions with which the surgeon has to deal. In several recent articles the common types of such injuries, the causes of their occurrence, and suggestions for their avoidance have been discussed. The most important injury is division, crushing, or resection of a portion of the common or hepatic ducts. The chief cause for such accidents in cholecystectomy lies in failure accurately to identify the cystic duct. The various anomalous relations which the cystic duct may hold to the hepatic and common ducts may easily lead to damage of the deeper ducts if the cystic duct is not carefully isolated before it is clamped and divided. Careless or hurried attempts to grasp a bleeding cystic artery (especially, if it has retracted into a position close to the hepatic duct) may result in clamping and ligating the hepatic or common duct.

*Unintelligent Use of Drains.*—In no case of the series was there clear proof that the pressure of a drain was solely responsible for the fistula. It is quite conceivable, however, that conditions productive of fistula could be brought about by gauze becoming adherent to the wall of the common duct already injured by pressure of a stone, or by forceps. One case illustrates the fact that drainage, prolonged far beyond the reasonable time, may be sufficient to establish a permanent drainage tract. The tendency of late is to use less and less drainage in surgery of the gallbladder and ducts, and, indeed, in general abdominal surgery. In selected cases of cholecystectomy drainage may be safely omitted. In 286 cases observed during the last three years the results of such procedure have been satisfactory.

*Reformation of Stones.*—Finally, in those cases in which the fistula closes for a varying time after operation and then reopens, the formation of stones must be mentioned as a possible factor, and in some instances apparently as the sole factor. In Table 1 is given the average length of time fistulas had been present in the various types of cases, the average varying from four and one-half months in cancer of the pancreas to thirty-seven months in cases of "stones in the gallbladder." Why such a difference of time should exist in these groups is readily understood. It is not easy to explain, however, since the question is chiefly one of the reformation of stones, why such long periods intervened in some cases before the reopening of the fistula which had closed normally after operation. It may be accepted that stones can remain in the gallbladder many years without producing sufficient obstruction to reopen the drainage tract to the surface; but it is difficult to believe that a stone could remain long in the common duct without sufficiently raising the pressure of bile to divert it through its former external communication, or to cause symptoms sufficient to indicate its presence or to necessitate operation. Available evidence supports the view that when the original operation is thoroughly carried out, actual reformation of stones in any portion of the biliary tract is exceedingly rare, but it may occur in the gallbladder, or in a common duct even if the gallbladder has been removed. The tendency to the reformation in the common duct is greater in cases in which there has been long continued dilatation and infection from an obstructing calculus. Following the removal of such a stone, the duct may become plugged with a soft type of pigmented stone which does not contain cholesterin, and a secondary operation becomes necessary within a few months. In three cases such stones have reformed a third time, and have been removed. A cure finally resulted in all.

Although it is seldom possible to attribute definitely the conditions which produced the fistula to any certain one of the causes which we have just discussed, it should be emphasized again that in only sixteen cases in the entire series had the gallbladder been removed at the original operation, and, exclusive of the cases of operative injuries to ducts, in only three cases had cholecystectomy been performed.

#### INDICATIONS FOR SURGICAL INTERVENTION

The indications for the operative repair of a fistula depend to a large extent on the length of time the fistula has been draining, on its behavior from day to day, and on the cause and probability of its persistence. It is fortunate that there is no objection to allowing ample time for a fistula to close spontaneously. The general health of the patient is not seriously disturbed, nor is the operation made more difficult by continued drainage, so that the hope that it will cease of itself justifies postponement of operation for a reasonable time.

When some portion of the biliary tract has been left open, such a wide variation exists, under normal conditions, in the duration and quantity of drainage that unnecessary apprehension is sometimes occasioned by continuance of drainage much beyond the usual time limits. The reason for such variation has not been determined. Apparently, it does not depend on the operation, for in choledochostomies, for example, after the tube in the common duct has been removed, bile drainage ceases immediately in some cases, and in others lasts for days. A probable reason for such variability may be found in the character of sphincteric control at the ampulla. Because of such normal variability, no very definite time limit can be laid down as a basis on which to determine the wisdom of surgical interference. A study of the postoperative records of the Mayo Clinic, however, shows that bile drainage rarely persists beyond three weeks after the last drains have been removed. If, at the end of that time, a large quantity of bile is continuously draining through the incision and only a small amount is entering the intestine, it may well be suspected that some mechanical obstruction exists, and that this obstruction will not of itself disappear.

In cases in which the drainage entirely ceases and then reappears, recurrence of discharge is frequently preceded by attacks of pain and jaundice, with possibly chills and fever, all of which disappear after the drainage tract reopens. Recurring fistulous activity, accompanied by such signs and symptoms, is almost a certain indication of obstruction of the common duct by a ball valve stone.

It should not be forgotten, however, that obstruction of the common duct by cancer of the head of the pancreas may be temporarily and sufficiently relieved to permit passage of bile into the intestine, with consequent closure of the fistula for a short time. The alternate closing and opening of a fistulous tract may also be a manifestation of stone obstructing the cystic duct or the pelvis of the gallbladder. In such cases, the signs and symptoms preceding reactivity are limited to pain, local soreness, and possibly a tender palpable gallbladder, while a discharge of mucus, possibly slightly tinged with bile, is further definite evidence that the gallbladder is shut off from the remainder of the biliary tract.

What length of time external drainage of bile may continue without evident effect on the general health of a patient is an interesting question. In this series the longest reported period that a fistula had existed was eleven years; in this instance all the bile had not been diverted to the surface. The longest time during which all of the bile drained to the surface was three years. In this case, at the third operation, four stones, each about 3 cm. in diameter, were found in the common duct. Following a cholecystostomy elsewhere three years previously, bile had

drained copiously and the stools had almost continuously been clay-colored. A tube had been in place for two years. There was no jaundice: the hemoglobin, however, was only 35 per cent. at the time of the operation. The patient showed neither definite disturbance in gastro-intestinal function nor recognizable nutritional disorder other than anemia. In another patient with stone in the common duct, apparently all the bile drained to the surface for eighteen months. The longest periods of drainage in cases of injury to the duct were twenty-one months and twelve months (Table 3).

TABLE 3.—PROLONGED DRAINAGE OF ALL BILE TO THE SURFACE  
(Thirty-Four Cases)\*

Causative Factors	Cases
Stone in the common duct.....	10
Division of the common duct.....	12
Stricture of the common duct.....	6
Carcinoma of the pancreas.....	3
Chronic pancreatitis.....	2
Stone in the hepatic duct.....	1
Average duration of complete fistula, seven months.	
There was a total of ninety-three operations in this group (here and elsewhere, including primaries).	

\* It is obviously difficult to establish absolute evidence of complete fistula (all bile). The evidence was carefully considered and only those cases that were fairly certain were included.

Preoperative diagnosis is always desirable, and we have already indicated some of the points on which a diagnosis may be established. In certain cases, especially when malignancy is suspected in the pancreas or in the duct or liver, a preoperative diagnosis is essential to the best interests of the patient. In cases of doubtful diagnosis, operation may well be deferred since the further course of the disease will settle the question. Sometimes the history of symptoms leading up to the original operation, in particular, the development of painless jaundice, associated with steady, progressive emaciation, together with the findings reported at operation, will give reasonable certainty to a diagnosis of malignancy and will justify advice on that assumption. If it is known that the common or hepatic duct has been injured, or if injury is suggested by a history of repeated operations, the surgeon must decide whether he should undertake one of the most difficult of all abdominal operations, namely, restoration of biliary function by reconstruction of the ducts.

#### SURGICAL TECHNIC

The operative management of biliary fistulas varies within wide limits. The cure of gallbladder fistula by removal of a stone impacting the cystic duct is quite simple and satisfactory. On the other hand, nothing can exact more surgical ability and experience than an attempt to restore the normal course of bile after several previous efforts have been made to repair the ducts.

By avoiding adhesions in the field of the former operation, it is surprising how much the operation for repair of a fistula may be simplified. This is accomplished by placing an incision beginning in the costosternal angle well to the median side of the former incision and the site of the discharge. Such an incision gives also much more direct access to the biliary ducts, which, regardless of preoperative findings, must always be thoroughly explored. The advantage of approach to the common duct through the upper end of such an incision is so great that, even though several prolonged operations to discover the cause of the fistula have previously been performed, a common duct stone may often be located and removed with ease. Location and removal of overlooked calculi, which are the commonest single cause of persistent fistulas, can easily be effected without much difficulty. If the gallbladder has not been removed, its early separation from the abdominal wall will facilitate the exploration and the steps of the operation. Before a complete examination of the operative field has been made, the gallbladder should not be removed, for it serves a most valuable purpose when irreparable damage has been done to the common duct, or when there is malignancy in the duct or pancreas. Further, if it seems likely, but not certain, that a permanent and satisfactory repair can be made of a strictured common duct, the conservation of the gallbladder anticipates a possible recurrence of stricture in the duct, and, by means of subsequent anastomosis, provides a way for the diversion of bile to the gastro-intestinal tract directly through the gallbladder. When such an anastomosis becomes necessary, the stomach or duodenum may be made use of equally well. With the exception, then, of a very few cases in which the preservation of the gallbladder is justified for reasons mentioned, the organ should be removed because of its disposition to cause future trouble.

A satisfactory method of cholecystectomy, such as that described by Judd,<sup>2</sup> should include as its most important feature the accurate identification and isolation of the cystic duct. When the gallbladder has been previously removed, its usefulness as a guide in operation will be missed. In ordinary cases, however, the absence of the gallbladder is not of consequence, for as a guide its place is well taken by the gallbladder notch of the liver.

In a patient who has already had the gallbladder removed, who has had one or more reconstructive operations on the ducts, and who suffers from chronic jaundice with its attendant liver and blood changes, the repairing of a biliary fistula due to an extensively damaged or excised common or hepatic duct offers the most difficult situation which may

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2. Judd, E. S.: Surgery of the Gallbladder and the Biliary Ducts, *J. A. M. A.* **71**:79-82 (July 13) 1918.



confront a surgeon. Experience in the Mayo Clinic has demonstrated that the most satisfactory method, and in many instances the only method, of dealing with such cases is to make a direct anastomosis between the hepatic duct and the duodenum. This method, the principles of which were first described by W. J. Mayo in 1905,<sup>3</sup> is so successful that the operation of hepaticoduodenostomy can be regarded as serving the same excellent purpose as cholecystogastrostomy or cholecystoduodenostomy when the gallbladder is present. The technic of hepaticoduodenostomy, at present preferred and practiced in the clinic, has been described in a recent paper.<sup>4</sup> The method is characterized chiefly: first, by the use of a duodenal flap (as originally advocated by Walton<sup>5</sup>), which is wrapped around the posterior aspect of the stump of the hepatic duct, thus forming a trough for the duct; second, by a large opening in the duodenum, and third, by the consequent closing of the duodenal opening by fixation to the capsule of the inferior surface of the left lobe of the liver. The large duodenal opening and the manner of closing it prevents subsequent contraction on the end of the duct, with the intermittent or chronic jaundice which so frequently complicated former methods of uniting the hepatic duct and duodenum. When direct union of a severed common duct, or excision of a stricture, neoplasm, or cyst of the duct, is necessary, one of the methods described in detail by Eliot<sup>6</sup> may be employed.

#### RESULTS

In this series of operations in 166 cases of biliary fistulas there were sixteen deaths, a mortality of 10 per cent. In operations undertaken for various conditions which were responsible for fistulas, the percentage of deaths shows very clearly the relative risks which accompany these operations. For instance, in thirty-five cases of stone in the cystic duct, no operative mortality occurred, while in the groups "division of the common duct" and "stricture of the common or hepatic ducts," six deaths in twenty-one cases were due largely to chronic jaundice and sequelae so common in such cases. The general rate of 10 per cent. mortality for the entire group is unfortunate when compared to that of from 1 to 2 per cent. which accompanies adequate

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3. Mayo, W. J.: Some Remarks on Cases Involving Operative Loss of Continuity of the Common Bile Duct, *Ann. Surg.* **42**:90-96, 1905.

4. Balfour, D. C.: The Technic of Hepaticoduodenostomy with Some Notes on Reconstructive Surgery of the Biliary Ducts, *Ann. Surg.* **73**:343-347 (March) 1921.

5. Walton, A. J.: Reconstruction of the Common Bile Duct, *Surg., Gynec. & Obst.* **21**:269-275, 1915.

6. Eliot, E., Jr.: The Repair and Reconstruction of the Hepatic and Common Bile Ducts, *Surg., Gynec. & Obst.* **26**:81-102 (Jan.) 1918.

primary operations on the gallbladder and ducts. Ten per cent. mortality can, however, not be looked on as excessive for a group of cases so frequently presenting such serious surgical complications. In considering ultimate results, the first question, of course, is, What degree of success has attended the primary purpose of the operation, the closure of the fistula? Of the eighty-three living patients from whom we have been able to secure positive information, eighty (98 per cent.) have been completely relieved of fistula. The health of patients who have reported is generally good, exceptions being chiefly confined to patients undergoing reconstruction operations on the deeper ducts. Of the entire series of patients, twelve reported occasional attacks of pain and jaundice; these were distributed as follows: "stone in the common duct," five; "stone in the cystic duct," two; "division of the common duct," two; "stricture of the common duct," two, and "stricture of the cystic duct," one. As a final observation, it may again be noted that, exclusive of the thirteen cases of duct injuries, in only three of the remaining 153 cases had the gallbladder been previously removed.

This review of the series of 166 cases of postoperative biliary fistula has shown: (1) the variety of conditions which may be responsible for a persisting fistula; (2) the more common causes for the presence of such conditions; (3) the duration of some fistulas; (4) the surgical management of fistulas, and (5) the excellent results obtained by radical surgical measures.

# THE SUSPENSION TRACTION TREATMENT OF FRACTURES OF THE LONG BONES NEAR LARGE JOINTS \*

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The underlying principles which make for efficiency in the suspension traction treatment of fractures of the long bones are now well understood. Foremost among them is that this form of treatment takes into full consideration the necessity of caring for the damaged soft parts. Full recognition is given to the truth that in many instances muscular, fascial and joint repair are far more important in restoring a properly functioning limb than absolute anatomic restitution of the bone. This form of treatment also accepts the truth of the teaching of Lucas-Champonnier, that complete fixation of fragments is not necessary for proper callous formation, in fact, may be detrimental to it.

In addition to these, the traction suspension treatment affords the best means of placing the distal fragment in proper alinement with the proximal fragment. In every fracture of a long bone, two elements enter into the resulting deformity. Either a proximal fragment is drawn from the planes of anatomic rest, while the distal fragment assumes such position, or the distal fragment is drawn out of the planes of the normally placed proximal fragment. Not infrequently, these two elements are combined. As a rule, the first effect is more marked when the fracture line lies near the proximal end of the bone, while the second is more prominent when the fracture line lies near the distal end. Almost universally, the surgeon has better control over the distal than the proximal fragment. Therefore, treatment aims so to place the traction suspension forces that the former is drawn into proper alinement with the latter. Occasionally, it is helpful to supplement this with traction applied to the distal end of the proximal fragment. Our means for doing this are, as yet, not over adequate; but I am inclined to believe the method of Heitz-Boyer can be made to find a wider application than it has enjoyed.

It is my belief, that with proper attention, practically every fracture through the middle third of a long bone can be successfully treated by the traction suspension method, and that the results will be more promptly obtained and better functionally than by other methods. In other words, I have found the principles of this method sound and

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\* Read before the American Surgical Association, Toronto, June 14, 1921.

their application possible with this type of fracture. It must be emphasized, however, that the application is often beset with difficulties, and that patient, untiring effort will alone be rewarded with success. It is a method that can be applied only after considerable experience, and with attention to detail that many surgeons are unwilling to give. Its success, therefore, depends on the opportunity to see and treat a considerable number of cases, coupled with a recognition of the fact that the expenditure of time and care will bring a satisfying reward. The hospital service—Cornell Division of Bellevue Hospital—where our study has been carried on, furnishes in abundance the former, and has been fortunate in having on its staff two men (Dr. Kenneth Bulkley and Dr. James Worcester) who have furnished the latter, and by their enthusiasm, inculcated their confrères with the desire to continue the work.



Fig. 1.—Dr. Worcester's modification of tongs, with blunt conical points to prevent too deep penetration.

As a result of our experience, I repeat that only very exceptionally do we encounter a fracture in the middle third of a long bone which cannot be successfully treated by the traction method. Every fracture is made an emergency case in that its treatment is immediately undertaken on admission. A preliminary roentgenogram is taken. The method of applying traction in fractures of the femur is by means of the ice tongs, as modified by Dr. Worcester (Fig. 1), and suspension is obtained by the Thomas splint and the Balkan frame (Fig. 3). In an adult male, the initial weight applied is 25 pounds or more. This is reduced when the roentgenogram indicates that it is possible. It cannot be overemphasized that the immediate application of sufficient weight to overcome the shortening is all important. Over pull is preferable to under pull. Too little weight at first results in a fixation

of the injured muscles in a shortened condition, and necessitates later a far greater weight than would have been initially needed. The suspension is done in the recognized way, so that active and passive motion (by means of pulleys) of both the hip and knee are at once begun. In humeral fractures, the traction is obtained either by adhesion to the skin or by means of the Henniquen band around the flexed elbow. From 5 to 8 pounds is sufficient, and either method will support this without difficulty. The suspension is by means of a specially constructed addition to the Balkan frame, which permits traction at any angle with the trunk (Fig. 4). Fractures in the shaft of the leg are usually drawn into direct alinement without difficulty. Occasionally, however, badly comminuted fractures show a persistent deformity which can

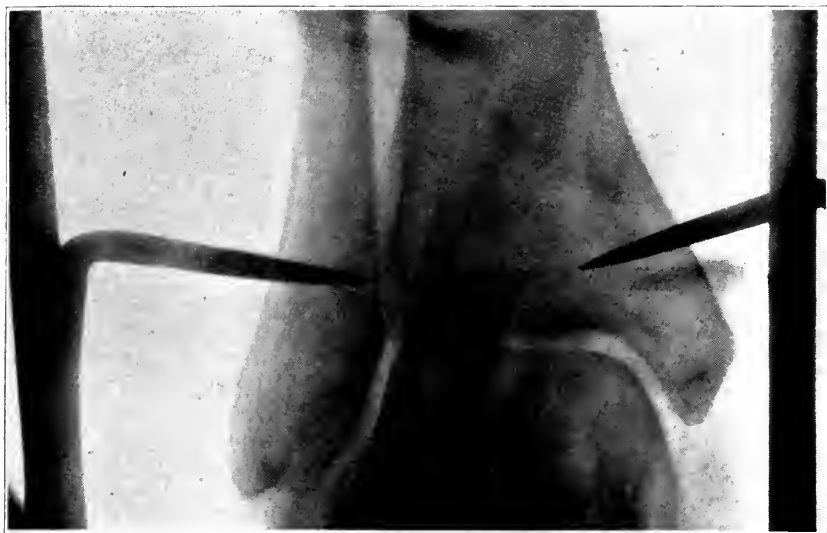


Fig. 2.—Tong points too tapering. They penetrate too deeply.

be readily overcome by tong traction on the malleoli or os calcis, or by the Henniquen band if low, or skin traction if high. Our success with the Sinclair skate has not been satisfying.

What has been stated concerning our satisfaction in this method of treating fractures through the middle third of the long bones, cannot be said with the same degree of satisfaction concerning fractures near the large joints. However, our experience here leads us to believe that further study will overcome the difficulties we have encountered, and we are satisfied that in the end such fractures will yield a higher percentage of good results by this method than by any other.

It must be emphasized that a perfect anatomic repair of a bone, accompanied by a badly crippled joint, is far more disturbing to the

patient than a poor position of the fragments with a well functioning neighboring joint. In many cases a proper reposition of the fragments has in my hands proved impossible. Nature, however, has responded more than satisfactorily in her ability to reestablish a range of motion in the joint which permits of all essential activities.

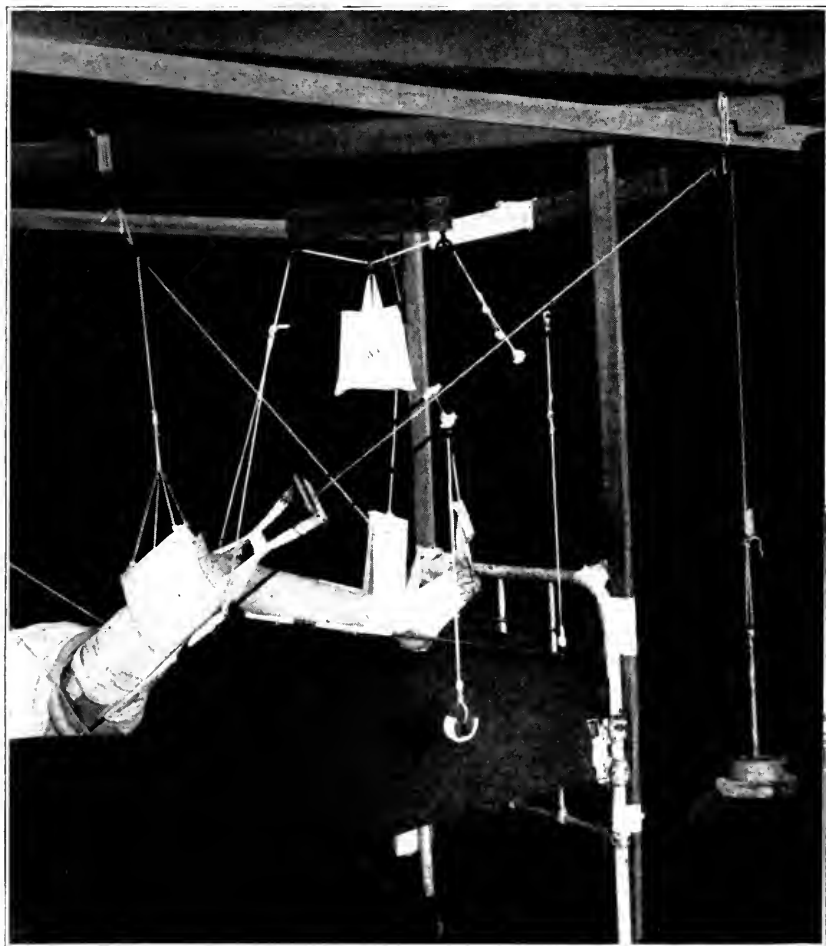


Fig. 3.—Suspension in Balkan frame for a high fracture of the femur with skin traction, illustrating outward rotation, abduction and leg flexion splint attached to the Thomas splint. When only moderate traction is needed, it can be obtained by skin adhesion on the thigh, still allowing knee movements.

Fractures near the hip, the knee, and the shoulder have received the most attention.

When the femur is fractured somewhat below the tuberosities, the upper fragment usually assumes a more or less constant position of

external rotation, and abduction, by reason of the stronger group attached at the greater tuberosity, and of flexion because of the direct pull on the lesser trochanter. The extent of these forces varies greatly according as the fracture is near or removed from the line of the tuberosities. If placed some inches distant, so that some fibers of the

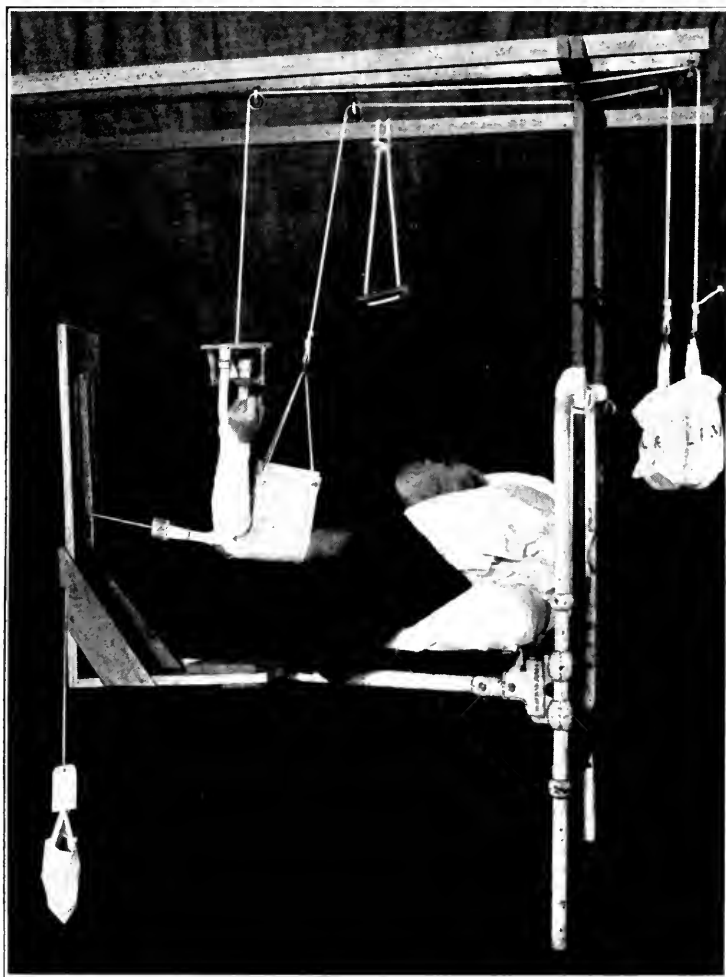


Fig. 4.—Traction of arm in only slight abduction. The amount of abduction is modified as needed by means of the hinge between the mattress board and the horizontal board. The elbow is lowered or raised by the movable pulley attachment within the slot on the vertical support.

abduction group remain attached to the upper fragment, this portion of the femur may be drawn into abduction, and neither external nor internal rotation is present. Moreover, in some instances, the fracturing

violence may cause unusual positions of the fragments, at the time of injury. The fractured ends having penetrated deeply into the muscle and fascial structures are prevented from taking up the positions



Fig. 5.—Subtrochanteric fracture without either abduction or external rotation of the upper fragment. This fragment is held in slight adduction by the pull on the adductors exerted by the lower fragment being drawn well upward and inward. The fracture was caused by violence applied directly to the external aspect of the femur at the point of fracture, with sufficient force to displace it well inward.

resulting from the abnormal muscle pull alone. We have thus come to learn that one may not rely on a knowledge of muscular action only to predicate the position of the fragments even in such classical



fractures as subtrochanteric or those through the surgical neck of the humerus. Dependence must, in the last analysis, be placed on the roentgen ray, and, therefore, the treatment of fractures can be carried out properly only when a bedside apparatus is continuously available.



Fig. 6.—Same fracture as in Figure 5, twenty-four hours after applying tong traction of 25 pounds. The overriding is corrected; but the upper fragment is still adducted.

These points are all well illustrated in the case of a woman, aged 60, who, in a street fight, was knocked down and jumped on by another woman (Fig. 5). The violence was applied mainly to the upper right thigh. Admission to the hospital was three days after the injury. There was an obvious fracture about 3 inches below the trochanters,

with overriding of 2 inches. The upper end of the lower fragment was displaced inward and slightly anteriorly as might be expected. The upper fragment, however, was also adducted, and in normal rotation. A study of the condition, both by palpation and the roentgen



Fig. 7.—Same fracture as in Figures 5 and 6, showing better alinement which was obtained by placing the limb in adduction, with lateral counter pull by a sling placed around the upper end of the lower fragment.

ray, showed that the upper fragment was held in this position because of the pull of the torn adductor muscles, which were tightly stretched over the lower fragment. The latter, by the direct violence of the injury, had been forced inward and dragged the upper fragment with it.

An attempt to place such a fracture into proper alinement, by abduction of the limb with traction suspension, failed. A satisfactory position was obtained only by tong traction of 25 pounds applied above the condyles, with the limb suspended in adduction and some flexion.



Fig. 8.—High spiral fracture of femur together with fracture through the lesser trochanter; upper fragment rotated outward and abducted; satisfactory result obtained by the treatment shown in Figure 2. In such cases only moderate traction is needed.

Even though there was a delay of a week from the time of injury before this was done, the overriding was entirely reduced in forty-eight hours (Fig. 6), whereas five days of skin traction had completely failed.

After correction of the shortening, there was still inward displacement of the upper end of the lower fragment which could be corrected only by direct outward pull by means of sling and pulleys.

The functional result in this patient was most satisfactory. Movement at all joints was practically normal; union was firm, and the anatomic deformity in the bone could be known only by means of the roentgen ray. In consideration of her age, 60 years, her alcoholic habit, and the presence of Paget's disease, she continued to use an ambulatory splint for eight months.

It was this case which first emphasized the necessity of recognizing that dependence cannot be placed on muscle pull alone



Fig. 9.—Pertrochanteric fracture.

in determining the position of the fragments. Several days were wasted in an attempt to place the lower fragment in line with an upper fragment erroneously presupposed to be abducted.

A contrast to this case is shown in Figure 8. The fracture is higher, the lesser trochanter being attached to the lower fragment, and the line of fracture is spiral. The upper fragment is in marked abduction and outward rotation, the classical deformity. Suspension, tong traction of 25 pounds immediately after receipt of injury, reduced to 15 pounds after only twenty-four hours, and replaced by skin traction after four weeks, was the treatment used. The limb was placed in 45 degrees abduction, moderate flexion, and extreme external rotation. The knee was flexed to 45 degrees on a movable leg attachment to the Thomas

splint. There was complete union, with full motion at all joints, at the end of two months. The patient was up in a chair for a month longer and then discharged wearing a Thomas caliper splint. He has failed to report at the follow up clinic; but there can be no doubt of an excellent result as judged by the condition on discharge.

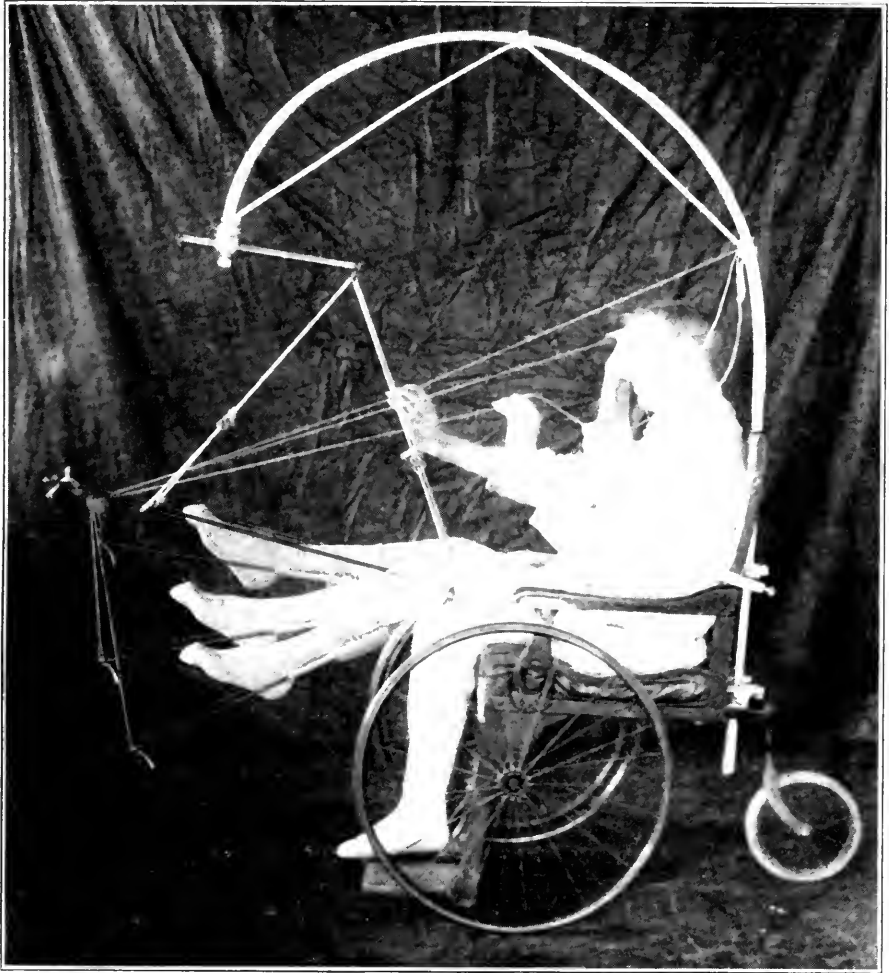


Fig. 10.—Dr. Rogers' attachment to wheel chair for carrying out all the requisites of traction suspension treatment. This should be used only when union is nearly complete and when only moderate traction is needed.

Our experience with the suspension traction treatment of fractures in immediate relation to the hip joint, either through the trochanter or of the neck proper, has not been extensive. It is sufficient, however,

to convince us that excellent results may be obtained with the former, and we can find no reason to believe that the latter also will not respond favorably.

A pertrochanteric fracture, involving the distal end of the neck, was received by a man, aged 36, when he fell down-stairs. He was immediately admitted to the hospital with the typical disability and deformity of this condition (Fig. 9). Treatment was by suspension in



Fig. 11.—Fracture through neck of femur, showing functional result after three months' treatment in traction suspension, with 15 pounds skin traction.

flexion, outward rotation, and 45 degrees abduction. The knee was placed in 45 degrees flexion on a movable leg attachment to the Thomas splint. Skin traction was used to the amount of 15 pounds for six weeks, and then reduced to 10 pounds. The patient was allowed to be up in a wheel chair with a Thomas splint attachment for suspension and traction (Fig. 10), devised by the resident surgeon, Dr. William

A. Rogers, for ten weeks longer. He was then discharged wearing the caliper splint. He reported six months after receipt of the injury, when the following condition was noted: "The patient walks normally. No limp. Has no pain in hip, but states that the knee becomes stiff when he doesn't use it. After walking a little, it is all right. The caliper brace was removed five and a half months after receipt of the

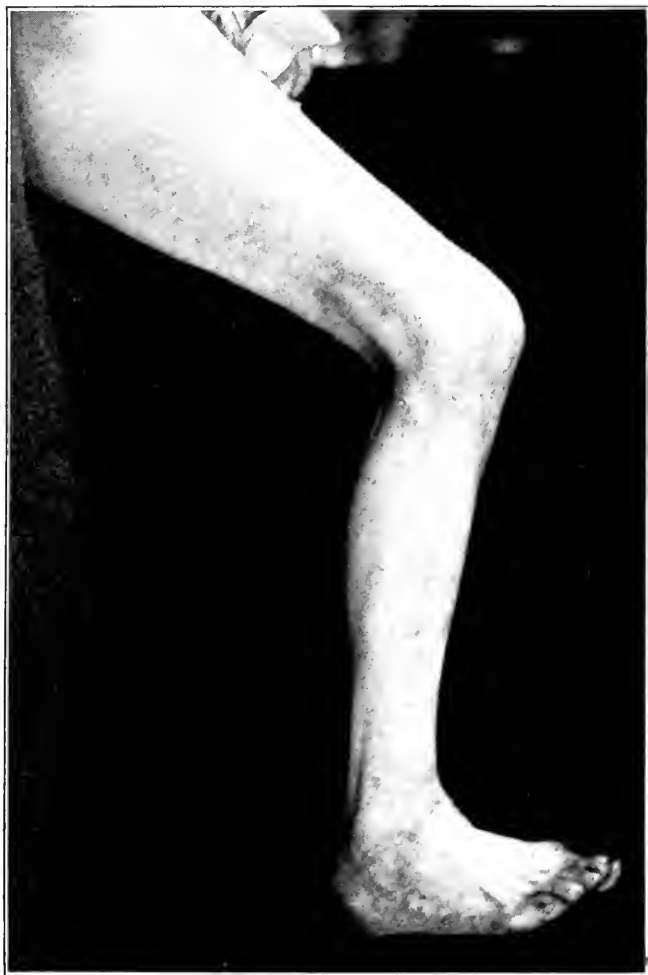


Fig. 12.—Fracture through neck of femur, showing functional result after three months' treatment in traction suspension, with 15 pounds skin traction.

injury." Complete restoration to a normal working condition, therefore, was present in this case in less than six months. The absence of muscular atrophy and joint disability is a noteworthy concomitant of this form of treatment as compared to its prevalence in complete fixation with plaster cast.

As stated, our experience in similar cases is limited; but there have been no failures, and the consensus of opinion of the staff is that the results are far more satisfactory than with fixation methods, and that the patients are, on the whole, far more comfortable.

A typical fracture of the neck of the femur is shown in Figure 11, and the outcome at the end of three months is shown in Figure 12.



Fig. 13.—Fracture of surgical neck of humerus, with the greater tuberosity completely avulsed. The upper fragment is turned so that the fracture line looks almost inward. This is hardly possible if the tuberosity remains attached to the proximal fragment. This patient was operated on with fair success.

This fracture was treated throughout with suspension traction in marked abduction and external rotation. Skin adhesion was used, and movements in the hip and knee were carried out from the first. The



result, after six months, was an entirely normal hip so far as weight bearing and range of motion were concerned. The roentgenogram showed a moderate coxa vara.

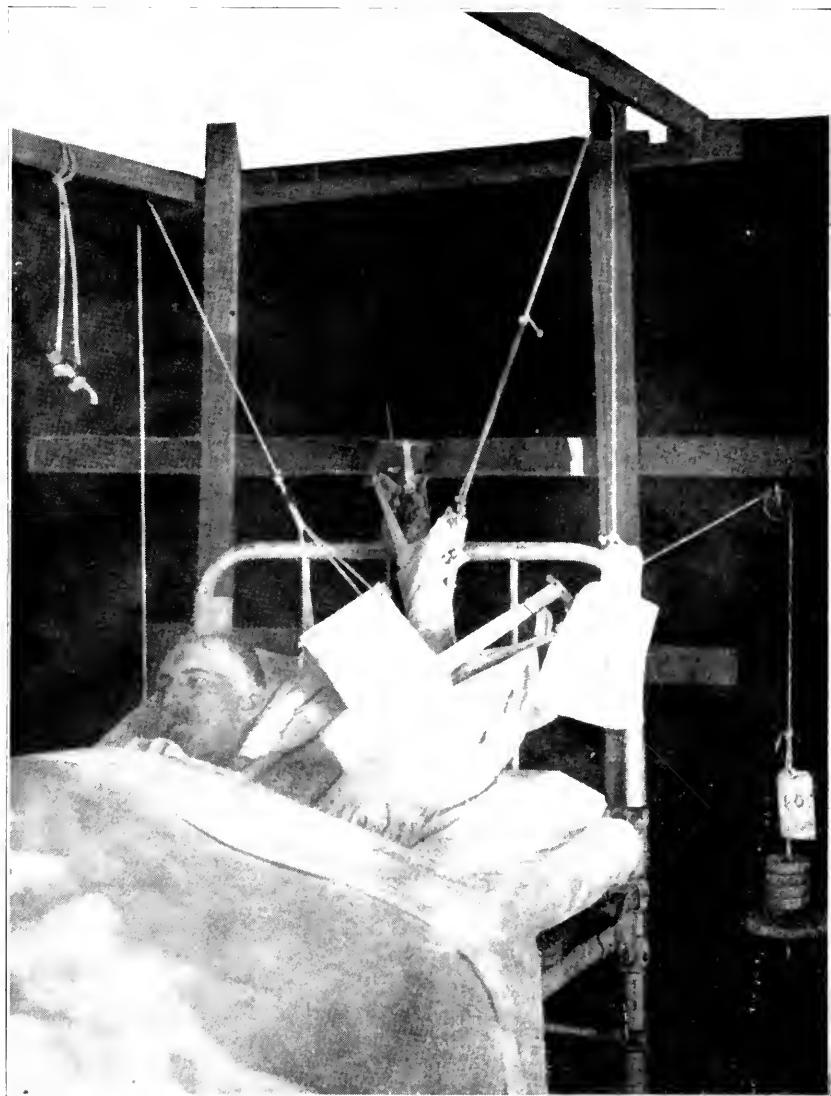


Fig. 14.—Extreme abduction and external rotation needed to procure proper alinement when a surgical neck fracture allows this exaggerated position of the proximal fragment by pull on the greater tuberosity.

Fractures in and about the shoulder joint show many similarities to those occurring in the upper end of the femur. The essential difference, however, in obtaining a satisfactory functional result is that the

range of movement in the shoulder is all important, while weight bearing without shortening is the prime consideration at the hip. For this reason, treatment of high fractures of the humerus must aim to procure union with the fragments so placed that joint obstruction will not take place and that muscular action may be efficient.

The usual deformity which results from a fracture through the surgical neck of the humerus is abduction and external rotation of the upper fragment. There are many exceptions, however, due to various causes. The most common is a coincident tearing off of the greater

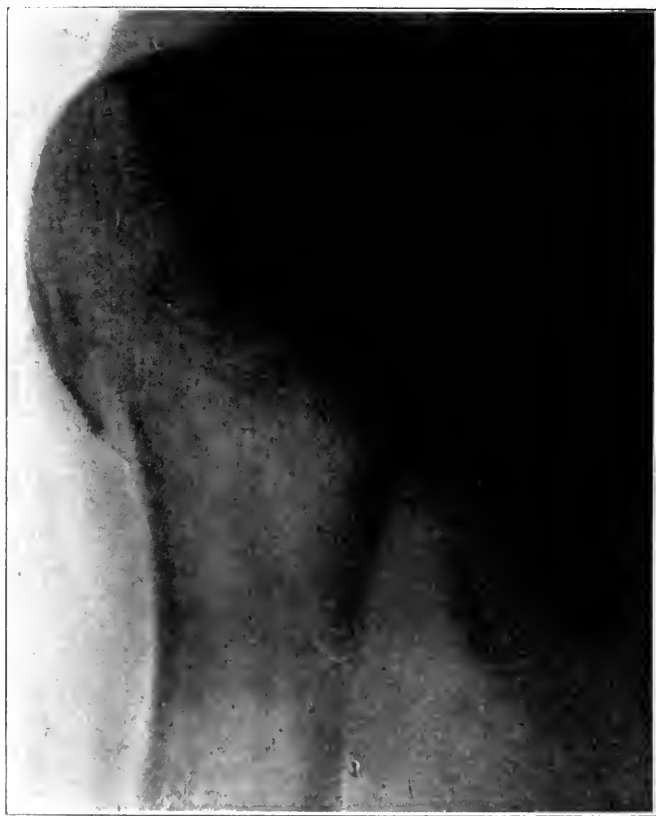


Fig. 15.—Upper fragment in surgical neck fracture is not abducted or rotated, because, as we believe, the muscular attachments are torn away without actual separation of the tuberosity. This fracture was at first treated in slight abduction and later full abduction and external rotation (Figures 4 and 14 are examples) with excellent result and full restoration of function.

tuberosity. This leaves the upper fragment uninfluenced by the muscles attached to this prominence, and it may assume any position, even to an amount of rotation inward so that the fractured surface faces

the glenoid fossa. Such a complete reversal results in leaving the upper fragment beyond control, and so far as we have determined, nothing can be accomplished by traction suspension in changing its position (Fig. 13). Open operation seems a necessity. On occasion, however, the inward displacement is not so complete, and then by placing the humeral shaft in the proper amount of abduction, the fragments are



Fig. 16.—Variations in position in fracture of surgical neck with tearing away of muscles from greater tuberosity.

well aligned. After from ten days to two weeks, there is sufficient union to cause the upper fragment to follow the arm as the abduction is increased from day to day. Finally, there is a hyperabduction and external rotation, which then brings the upper fragment in contact

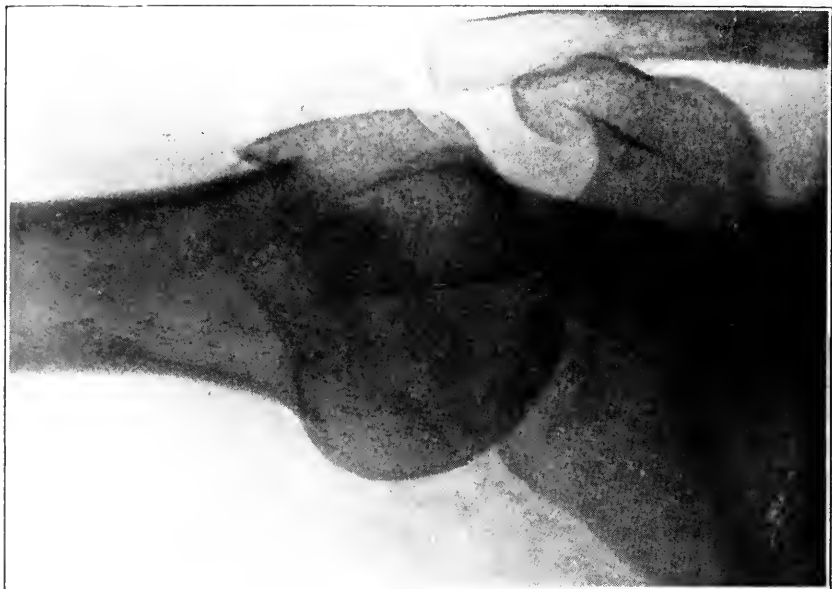


Fig. 17.—Variations in position in fracture of surgical neck with tearing away of muscles from greater tuberosity.



Fig. 18.—High spiral and comminuted fracture of the humerus, in abduction after partial union is established. The proximal fragment was drawn inward by pectoral major fibers.

with the abducted and externally rotated greater tuberosity. Union then results. On recovery the arm falls by gravity to adduction and internal rotation, by which the abduction and external rotation group are drawn out to their normal length, and hence can again function. It is important that some movement should be made in the arm constantly. The



Fig. 19.—Fracture near knee joint, with the lower fragment forward. Flexion of knee exaggerated this deformity while extension corrected it. This and Figure 20 represent the same angle and amount of traction (25 pounds) by tong attachment.

traction suspension treatment ideally furnishes an opportunity for this. Ten pounds is usually sufficient, applied by means of skin traction. The needed modifications in position are obtained by means of the support (Fig. 4) and direct traction (Fig. 14).

One must further recognize that inward rotation of the upper fragment may take place when the muscles or the periosteum are torn from the greater tuberosity without actual separation of the tuberosity itself. This injury need not show in the roentgenogram, though in some cases the periosteal stripping can be seen (Fig. 15). The impor-



Fig. 20.—Fracture near knee joint, representing the same angle and amount of traction (25 pounds) by tong attachment as Figure 19.

tance of this is found in the fact that unless the inward rotation is recognized, the arm may be easily placed in too great abduction. We have fallen into this error on one or two occasions.

Here again, when the fragments are sufficiently adhered, it is necessary to increase the abduction from day to day, so that the greater

tuberosity may be brought into contact with its separated and contracted muscular insertions.

Finally, the fracture of the surgical neck may run obliquely down the shaft so that portions of the pectoral major are attached to the upper fragment. This condition, with entanglement of the fragment



Fig. 21.—Late result: some deformity, but fair movement in the knee joint.

ends in this muscle and the deltoid or arm muscles, may produce bizarre positions.

The important consideration, therefore, is to obtain accurate information as to the position of the upper fragment, by means of the roentgen ray—no other examination will give this—and place the distal fragment by traction suspension in proper alinement with it. Ultimately,

however, the extremity must be brought into complete abduction—sometimes hyperabduction—and external rotation. During healing, a certain amount of active motion must be carried out, this being facilitated by proper counterpoising, so that the entire weight of the limb does not fall on the muscular pull.



Fig. 22.—Late result: some deformity, but fair movement in the knee joint.

The service has afforded many examples of these fractures, all of which have been treated along the lines here described. The functional results have been, without exception, excellent.

This form of treatment, of course, requires confinement to bed for a period of about four weeks. This is not too great a price to pay



for the obtaining of a thoroughly useful shoulder. Examples of these fractures are given in Figures 11 to 18, and the methods of obtaining the needed positions are illustrated in Figures 4 and 14.

Fractures of the femur near and involving the condyles present peculiar difficulties. The typical supracondylar fracture, with the lower



Fig. 23.—Fracture treated by suspension and traction by tongs in the os calcis, with excellent result.

fragment drawn directly backward, can easily be drawn into proper alinement by placing the tongs sufficiently far back and high enough to draw this fragment forward. This is accomplished by so arranging the supporting pulley that the line of traction is 45 degrees or more upward. The fulcrum then comes at the line of the condylar surface

against the patella and its ligament. This is made more efficient by flexion of the leg, and in the first days movements in this joint may be only minimal. After some days, however, the alinement can be maintained even when the leg is moved through a considerable arc. When, however, as illustrated in Figure 19, the lower fragment, by the fracturing force, is driven forward, while the upper fragment lags behind,



Fig. 24.—Comminuted fracture about femoral condyles, treated by suspension and traction on Steinmann pin through tibial head, for five weeks, with leg extended. Active motion on movable leg attachment then instituted.

we have been able to get proper alinement only by keeping the leg in extension. To do this sacrifices one of the great advantages of the method of treatment, namely, active movement. One must, therefore,

determine in each case whether the wise course is to obtain good alinement without active motion in the knee, or accept some deformity with a good functioning knee joint. In the case above cited, a middle course was followed with a fairly satisfactory result (Figs. 21 and 22), though the fracture was compound, with almost complete rupture of the quadriceps at the site of fracture.



Fig. 25.—The result.

The badly comminuted and displaced fractures involving the femoral condyles and knee joint present unusual difficulties. As a rule only moderate traction is needed; but the problem of securing this, and, at the same time of permitting knee movement, must be solved. Figure 24 shows such a fracture in a woman, aged 60 years, received by a fall

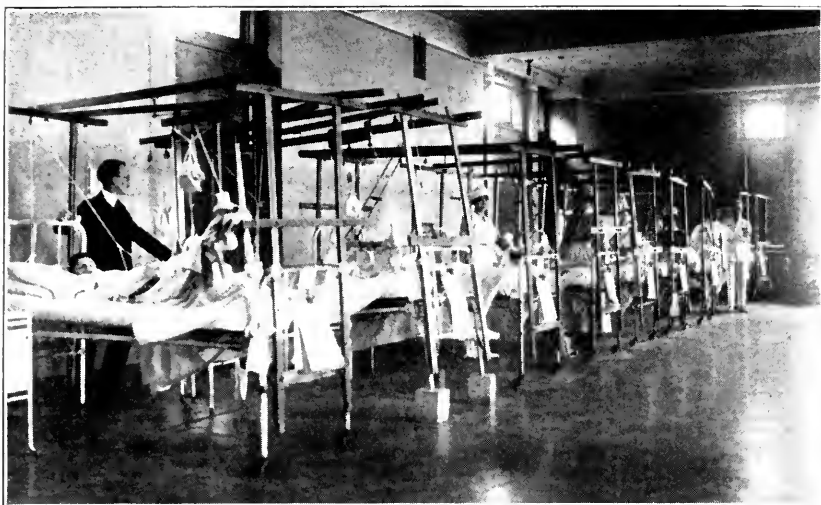


Fig. 26.—The fracture ward, showing the number of cases on a general surgical service of ninety beds.

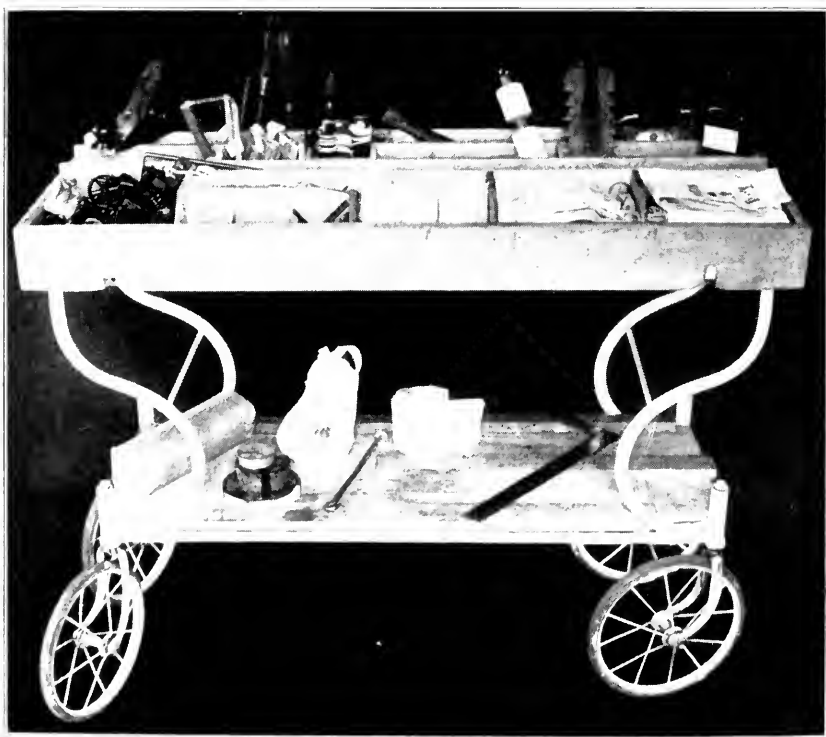


Fig. 27. The fracture truck assembled by Dr. Bulkley. This carries everything needed in applying suspension traction and is a most essential unit in the equipment.

of 8 feet and landing on the foot with leg extended. The treatment was by means of traction on the Steinmann pin through the tibial head, and suspension at first with the leg extended. After five weeks the movable leg attachment was utilized, traction removed, and active movement at the knee instituted. The result is given in Figure 25, when the function of the knee was excellent and the patient could walk without pain or limping. Flexion beyond a right angle was present.

No other similar case has come under treatment, but the outcome here indicates that the suspension traction treatment can be used to advantage.

The traction suspension treatment has also been found efficient in badly comminuted or long spiral fractures of the tibia and fibula near the ankle joint. The tongs may be placed either in the malleoli or the os calcis. Figure 23 shows one case of this sort treated with an excellent result. Our experience has led to the conviction that this method of treatment is deserving of careful study on the part of those treating fractures. In a hospital where fractures are treated in any number, it should constitute the standard treatment. Its possibilities, I believe, are greater than the results here shown. It is not, however, a method easy of use, and only by rather long intensive study may one perfect himself in the technic.

The study on the Bellevue service has been carried on by the entire staff. I desire particularly to express my appreciation to my former associate surgeons Dr. Kenneth Bulkley and Dr. James Worcester, who successively have had charge of the fracture work, and to the resident surgeon, Dr. Russell Patterson, who has taken most of the roentgenograms and given valuable aid in the preparation of this communication.

## THE RELATION OF SURGICAL TECHNIC TO GASTROJEJUNAL ULCER\*

C. A. ROEDER, M.D.

OMAHA

Previous to the performance of gastro-enterostomy for ulcer, we find the lesion practically always in the duodenum, pylorus, and lesser curvature. Following the operation, if a new ulcer occurs, it is practically always in the region of operative procedure, that is, in the jejunum, stomach, or on the rim of the anastomosis; occasionally a new ulcer occurs on an old suture line such as is found in the resected stomach. The location and the time of occurrence of the ulcers before and after gastro-enterostomies are so dissimilar that a different etiology is most strongly suggested. Reports of new peptic ulcers occurring after this operation must be carefully analyzed as such ulcers are generally the old ulcers reactivated, which had never healed, or are new ulcers in the region of previous surgical procedure. Can the latter be termed true peptic ulcers?

Gastrojejunal is the adjective used to describe the ulcer which occurs in the region of the anastomosis after gastro-enterostomy. The terminology, however, is not appropriate as it does not properly describe the regional occurrence. We should expect a gastrojejunal ulcer to involve always the stomach and jejunum. These postoperative ulcers are herewith listed in the order of their frequency: (1) in the jejunum close to the anastomosis; (2) along the edge of the anastomosis; (3) in the stomach close to the anastomosis, and (4) we might add another region, which is along the line of closure of a resected stomach. Regardless of whether or not they all have the same etiology and granting that they are all postoperative, the term gastrojejunal does not describe correctly such ulcers, nor does it designate their location since there are four distinct areas of occurrence.

One noteworthy feature of the so-called gastrojejunal ulcers is that they are always found in proximity to the region of operative procedure, that is, along the previous suture line or about where a clamp had been placed. The more or less constant regional occurrence suggests more or less constant etiologic factors, and this singular regularity indicates that these ulcers seek a certain soil. This characteristic is a most

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\* From the Department of Experimental Surgery, Nebraska University College of Medicine, Omaha.

\* Read before the first annual meeting in Nebraska of the American College of Surgeons, Omaha, March 3, 1921.

important point since we know that this soil did not exist before the operation. There probably is no one etiologic factor, which may also be true of peptic, duodenal and gastric ulcer, but it seems quite logical to assume that gastrojejunal ulcer must be due primarily to the change in chemistry, to the surgical technic, or to both. Infections from a distant focus or a general constitutional derangement can hardly be considered as primary factors.

The passage of gastric contents directly into the jejunum is regarded by many as the direct or primary etiologic factor for all types of gastrojejunal ulcer, but this can be considered only for those ulcers occurring on the jejunal side of the stoma. The change in chemistry is not so marked as has been taught. The rapid propulsion of bolus of food from

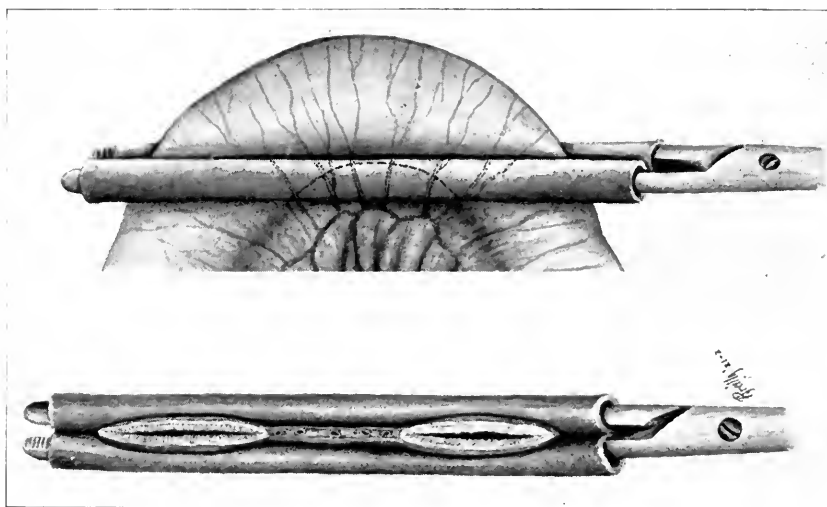


Fig. 1.—Lateral and cross-sectional view of jejunum in clamp. The inclusion of the mesentery may be noted, necessitating marked pressure on the jejunal walls to produce hemostasis.

the stomach, through the duodenum and upper jejunum, too fast to become thoroughly alkalized, suggests that acid as well as alkaline products pass through this segment and that it is not entirely alkaline in reaction. I have repeatedly allowed the tip of a duodenal tube to pass to the distal duodenum, and, after feeding a soft mixed meal, have obtained contents of marked acidity. Therefore in gastro-enterostomy a segment accustomed to marked acidity is joined to one accustomed to both alkalinity and acidity.

Perhaps no one factor can be assigned as the cause of the so-called gastrojejunal ulcer, but the terminology is nevertheless in need of revision in order better to describe the regional and relational occurrence

of one of the most serious complications of a gastro-enterostomy. These ulcers occur probably in not more than 5 per cent. of patients operated on, but as the operation is so frequently performed, their actual occurrence is of sufficient moment to open a new department of surgery in the upper abdomen. These ulcers present difficult surgical problems, which require no little resourcefulness, and an exceptionally good technic for their solution.

#### ULCERS OCCURRING IN THE JEJUNUM

The majority of these postoperative, gastrojejunal ulcers occur in the jejunum close to the anastomosis where the clamp had previously

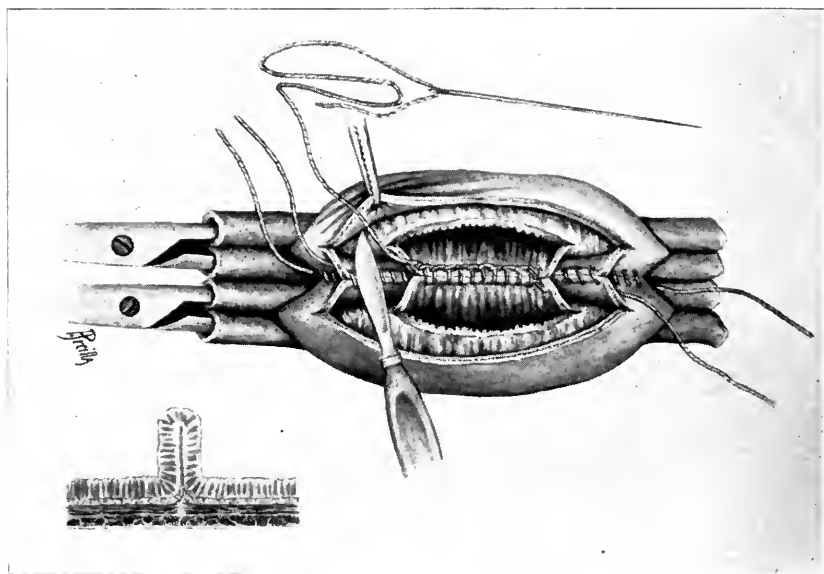


Fig. 2.—Gastro-enterostomy performed by author's technic. The separation of the mucosa from the muscularis for about one-fourth inch and the method of suturing may be noted. The mucosa is penetrated by the suture only along the edge.

been placed and in the area where so frequently an interrupted silk or linen reinforcing stitch had been placed. It is this ulcer which is attributed by many to be the result of contact of the gastric contents with a mucosa unused to any but a secretion with an alkaline reaction. The high acidity, however, rapidly decreases following this operation. The rapidity with which this acidity decreases is enhanced considerably by the alkalis which are so frequently administered during the post-operative treatment. Furthermore, the mucosa of the duodenum and upper jejunum resists acrid chemical secretions, and, as previously



stated, is not unused to acid contents. Since physiologic chemistry and biologic stamina are variables, a certain proportion of individuals are no doubt distressed and even injured by gastric secretions in the jejunum, but it seems hardly logical to state that all jejunal ulcers are due entirely to acid gastric contents.

It is significant that most ulcers in the jejunum occur close to or in the region where the clamp was placed. A portion of the jejunal mesentery is generally caught in the clamp (Fig. 1), which fact illustrates the amount of pressure necessary on the thick jejunal walls to compress sufficiently for hemostasis the much thinner jejunal



Fig. 3 (Dog 1).—Amputated end of stomach following Billroth II operation. The scar bound mucosa may be noted.

mesentery. How frequently during the performance of a gastro-enterostomy do we have to tighten the blades holding the jejunum because of the bleeding after it is opened, the pressure then becoming considerably greater than on the stomach. The trauma of the clamps, which is always severe, must, not infrequently, produce more or less injury to the jejunal mucosa and submucosa, sufficient injury, at any rate, to result in an immediate sloughing of an area of mucosa, or in deposits of scar tissue in it and the submucosa—a pre-ulcer condition or a factor predisposing to ulcer formation. The area of injury from the clamp, the point where frequently the reinforcing interrupted non-

absorbable suture is placed, the portion of the intestine where the gastric secretions first strike the jejunal mucosa, and the region where most jejunal ulcers occur form a significant combination of coincidences.

#### ULCERS ALONG THE EDGE OF THE ANASTOMOSIS

Postmortems a few weeks or more after a gastro-enterostomy reveal very plainly, along the suture lines of the anastomosis, mucosa bound down by a scar which is in marked contrast to the healthy, adjacent mucosa. Because of its rugous formation a normal mucosa in the stomach and jejunum enjoys marked excursion over the layers beneath it; it also possesses a very free blood supply. Few attempts have ever been made to simulate nature in operative technic as is

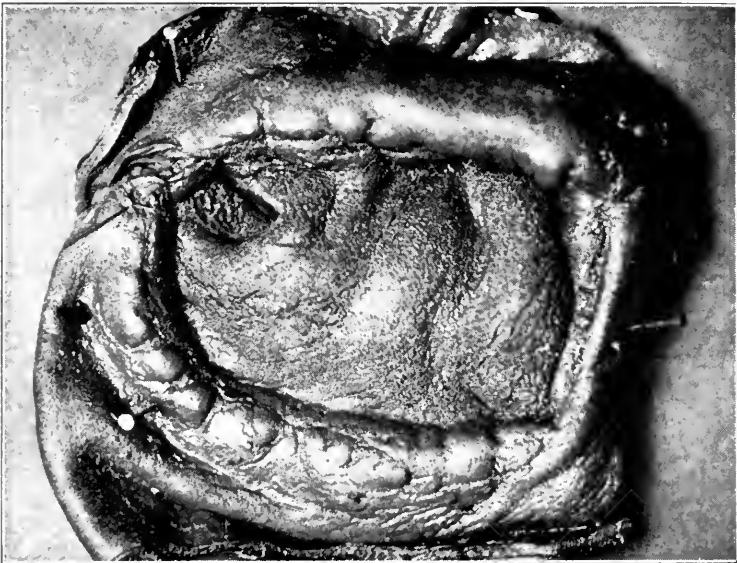


Fig 4 (Dog 2).—Gastro-enterostomy opening looking into the jejunum. The presence of scar bound mucosa along the edge of anastomosis may be noted. The scar binding effect of the suture passing through all three coats of the stomach and bowel wall is plainly seen.

demonstrated by the mucosa bound down by a scar following surgical procedures, which might well be considered as a predisposing as well as a most important factor in the etiology of ulcers occurring on the postoperative suture line.

The vast majority of these suture line ulcers occur along the edge of the anastomosis; the remaining ones occur along the old line of suture in the resected stomach. As previously stated, they follow the absorbable as frequently as the nonabsorbable suture, but I am unaware of a nonabsorbable suture reported as partially retained in the end

of a resected stomach, which may be due to a better union here than between gastric and jejunal tissue. Gastric secretions may be of greater potency in the latter region (the anastomosis) because of the slightly more sensitive jejunal mucosa. There is no dispute about the non-absorbable suture's being a direct factor in a certain percentage, but for those ulcers following the use of catgut it is very likely that the etiologic factor is the scar tissue which is susceptible to the corrosive action of gastric juice.

Of all regions requiring a healthy mucosa, it seems most necessary in the lining of a gastro-enterostomy. Contact with hot and cold foods, the acrid chemical secretions from the stomach and duodenum, together with the trauma from traction and food friction, strongly indicate that we must leave this area better prepared to resist injury than we have in the past.

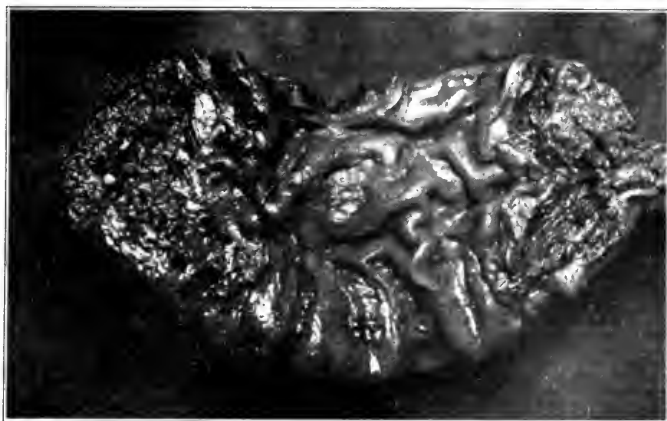


Fig. 5 (Dog 3).—Amputated end of stomach following resection of the pylorus. Absence of scar bound mucosa as seen in Figure 3 may be noted.

#### ULCERS OCCURRING IN THE STOMACH

The vast majority of ulcers occurring in the stomach following a gastro-enterostomy are found close to the line of anastomosis about where the clamp was applied and also corresponding to one of the areas where a deep interrupted, reinforcing Lembert suture of silk or linen was placed. This regional occurrence is similar to that of the jejunal ulcer, further indicating the probable significance of the clamp. The grip of the clamp is necessarily severe in order to hold the stomach in place, subjecting the mucosa to such trauma that it may even be divided as reported by Coffey. This trauma naturally results in Nature's response with an immediate slough or a scar tissue deposit in the submucosa—a pre-ulcer condition.

The occasional ulcers occurring elsewhere in the stomach following a gastro-enterostomy are generally reported as being of the true peptic type. From my study of such reports, it is quite evident that not all of these ulcers are of this variety and that they will generally be found along the line of the previous suture. Since these ulcers have never existed before, they cannot be classed as recurring. With these ulcers in the stomach, the acidity is a normal environment, and even that is greatly reduced after the operation, thereby further signifying that the chemical condition is merely a contributing or secondary factor.



Fig 6 (Dog 4).—Gastro-enterostomy opening looking into jejunum. The absence of scar bound mucosa may be noted.

#### COMMENT

It is evident that the so-called gastrojejunal or postoperative ulcer is found in the region of previous operative procedure, and since we know Nature's constant response is always scar tissue, we must give this reaction primary consideration relative to the etiology of this ulcer, submitting it as probably the most important predisposing factor. This seems fairly logical as we are beginning to conceive that no ulcer, peptic or "postoperative," has one direct causative factor and that the greatest number occur in certain areas which require a certain soil, namely, a localized anemia.

The use of the absorbable suture has marked a distinct advance in gastric surgery, but the technic is still in need of considerable

refinement. The trauma from our improperly constructed clamps and our methods of suturing has been greatly underestimated; and we have not made sufficient effort to leave the field of operation as we found it. The mucosa is the most important layer and must be kept in mind as occurring normally in a superabundant and rugous formation in the jejunum and more so in the stomach. Every bit of it should be preserved during the operation, and it should never be penetrated by a suture excepting closely along the edge. The use of mass sutures which pass entirely through all three coats has a most pernicious influence on the mucosa, first, by strangulation, and later, by immobilizing it with scar tissue. This method also shuts off the necessarily

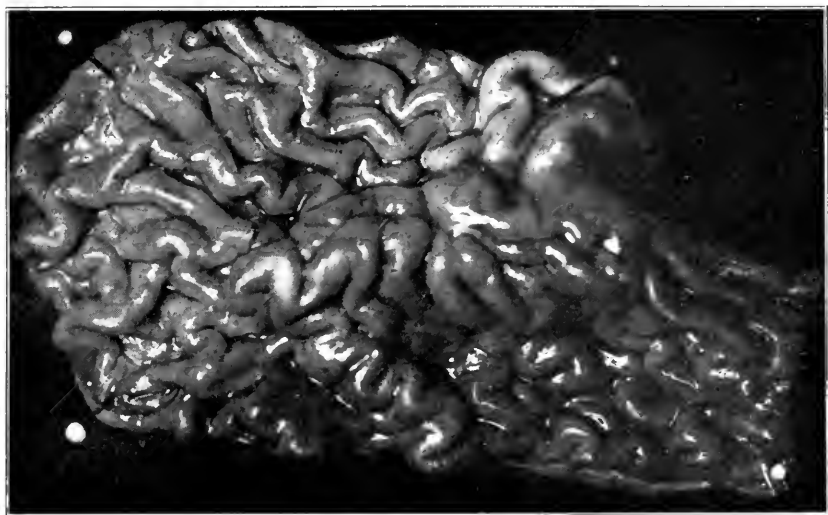


Fig. 7 (Dog 5).—Transverse incision made through the anterior wall of the stomach. The absence of scar bound mucosa may be noted.

abundant blood supply of the mucosa. The avoidance of hard knots of numerous ligatures seems essential as they must remain as foci of infections causing future trouble. It seems reasonable to state that if any mucosa remains in superabundance, enjoying ample excursion and a normal blood supply, no ulceration can result in any portion of the gastro-intestinal tract. Following the ordinary technic, an immobilized, thinned, and scar-bound mucosa is the usual picture seen a few weeks, or later, along the line of previous suturing. Any postmortem examination will demonstrate this. Such mucosa, together with the trauma from clamps and interrupted reinforcing sutures, signifies that other factors must be seriously considered besides the acid gastric contents as the etiologic factor in postoperative ulcer production.

## TECHNIC

The results of the technic to be described simulate more closely the natural conditions than those following any other technic of which I am aware. It is not entirely original, as the mucosa has been sutured separately by others ever since the operation of anastomosis has been practiced, but there are a few features I have not found emphasized elsewhere.

The mucosa is dissected from the muscularis for about one-fourth inch (Fig. 2), not only to obtain a superabundance but also to have the edge of the combined outer coats free enough to be easily sutured separately. This dissection does away with any possibility of the second row of sutures ever penetrating the mucosa, preventing almost entirely the usual sloughing of the mucosa by the through and through suture and also its immobilization by scar tissue infiltration. The mucosa is also sutured separately and only along the very edge in order to have a rugous formation over the rim of the anastomosis, simulating as much as possible the normal lining of the stomach and jejunum. The second row of sutures takes in only the muscularis and serosa, having been dissected free from the mucosa. The outer or third row



Fig 8 (Dog 6).—Longitudinal incision in anterior wall of stomach. The suture line which is not scar bound and which is acceptable as a satisfactory union may be noted.

of sutures is the usual seromuscular, to relieve tension and assure that there is no leakage.

In this technic, the mucosa is sutured only once and then close to the edge, and every effort is made to prevent passing any portion of the two outer layers of sutures through it, which precaution leaves it as free as possible and with very little interference with its blood supply. No hemorrhage can possibly result as the mucosa is united with a lock stitch, and the two outer rows are plain running sutures, all perfect hemostatics if applied properly. Catgut only should be used in the two outer rows. Any type of suture, absorbable or nonabsorbable, may be used on the mucosa since it rapidly sloughs into the lumen.<sup>1</sup>

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1. Lewis, Dean: Personal communication.

In all resections of the stomach the mucosa should be as carefully preserved, which measure necessitates, whenever possible, the use of noncrushing clamps.

#### PROTOCOLS

EXPERIMENT 1.—Dog 1 was operated on Oct. 2, 1920, and necropsy was performed Dec. 3, 1920. The pylorus was resected and the ends of the stomach and duodenum were closed with two rows of sutures. The inner row of 0 chromic gut was passed through all the coats of the viscus, no attempt being made to suture the mucosa separately. The outer rows of fine silk were passed through the serosa and muscularis.

Figure 3 illustrates the closed end of the stomach after a few hours' immersion in a 10 per cent. dilution of liquor formaldehydi. Scar bound mucosa representing suture line may be noted.

EXPERIMENT 2.—Dog 2 was operated on Oct. 2, 1920, and necropsy was performed Dec. 3, 1920. An anterior gastro-enterostomy was performed, with two rows of sutures: the inner row of 0 chromic catgut passed through all



Fig. 9 (Dog 7).—Author's technic used in the upper half of the gastro-enterostomy opening, with absence of scar tissue. The usual through and through suture technic is used in the lower half, showing scar bound mucosa.

the coats of the viscus, no attempt being made to suture the mucosa separately; the outer row of 0 chromic gut, passing through the serosa and muscularis.

Figure 4 illustrates the gastro-enterostomy stoma after a few hours' immersion in 10 per cent. picric acid solution, which unfortunately removed the rugous formation in the mucosa surrounding the scar bound edge of the new opening, doing away with the contrast. The mucosa, however, plainly appears as thinned and scar bound.

EXPERIMENT 3.—Dog 3 was operated on Oct. 9, 1920, and necropsy was performed Dec. 3, 1920. The pylorus was resected with the ends of the stomach and duodenum closed with three layers of 0 chromic gut sutures. The mucosa was dissected free from the muscularis for about one-fourth inch and

sutured closely along the edge. The muscularis and serosa were likewise sutured, carefully avoiding the mucosa, and the third row of sutures was passed as the usual seromuscular, inverting the second row.

Figure 5 illustrates the closed end of the stomach after about one hour's immersion in a 10 per cent. dilution of liquor formaldehydi. The mucosa, which appears almost as free and thick as the surrounding tissue, may be noted and contrasted with Figure 1.

EXPERIMENT 4.—Dog 4 was operated on Nov. 20, 1920, and necropsy was performed Dec. 21, 1920. An anterior gastro-enterostomy, with three rows of 0 chromic gut sutures, was performed. The mucosa was dissected free from the muscularis for about one-fourth inch and sutured carefully along the edge. The muscularis and serosa were likewise sutured, carefully avoiding the mucosa, and the third row was passed as the usual seromuscular, inverting the second.

Figure 6 illustrates gastro-enterostomy stoma after a few hours' immersion in a 10 per cent. dilution of liquor formaldehydi. The free and abundant mucosa may be noted covering the suture line and appearing quite normal.

EXPERIMENT 5.—Dog 5 was operated on Nov. 20, 1920, and necropsy was performed Dec. 20, 1920. A transverse incision was made in the anterior stomach wall and closed with three layers of 0 chromic gut. The mucosa was dissected free from the muscularis for about one-fourth inch and sutured carefully only along the edge. The second row of sutures took in the muscularis as well as the serosa, carefully avoiding the mucosa, and the third row was the usual inverting stitch.

Figure 7 illustrates the inner aspect of the stomach and suture line, which is hardly discernible. The mucosa appears quite normal: abundant, mobile, and of normal thickness.

EXPERIMENT 6.—Dog 6 was operated on Nov. 20, 1920, and necropsy was performed Dec. 21, 1920. A longitudinal incision was made in the anterior wall of the stomach, and closed with three layers of 0 chromic gut. The mucosa was dissected free from the muscularis for about one-fourth inch and sutured carefully only along the edge. The second row of sutures took in the muscularis as well as the serosa, carefully avoiding the mucosa, and the third row consisted of the usual inverting stitch.

Figure 8 illustrates the inner aspect of the stomach and suture line, which is more discernible than in Figure 9, but acceptable as a union approaching the normal.

#### CONCLUSIONS

1. The adjective gastrojejunal improperly describes the type of ulcers following gastro-enterostomies since the term does not designate their regional and relational occurrence. Since these ulcers are a post-operative morbidity, the technic of surgical procedure should be more carefully studied.

2. The mucosa is the most important layer relative to chronic ulcer in any portion of the gastro-intestinal tract. During operations, it should be preserved to the utmost, simulating Nature as much as possible in the following respects: superabundance, marked mobility, and ample blood supply. This method is suggested by the fact that



preoperative and postoperative ulcers generally occur in the area where vascularity is comparatively less and where the mucosa is less abundant.

3. The mucosa should be sutured separately and only along the very edge; no other suture should ever penetrate this layer in order to prevent scar tissue infiltration and immobilization—the pre-ulcer condition. Whenever possible, the mucosa should be dissected free from the muscularis, which measure also allows the outer coats to be sutured separately with very little chance of including the mucosa.

4. The main object of this report is to emphasize that: (1) the so-called gastrojejunal ulcer is very likely the direct result of operative procedures; (2) every effort should be made to simulate Nature as much as possible by leaving the mucosa superabundant, with a free blood supply; and (3) in the technic of gastro-intestinal surgery, the mucosa should always be sutured separately close to the edge. No sutures should be passed through all three coats at one time since such a procedure strangulates the mucosa, later immobilizing it with scar tissue, which in addition shuts off the blood supply.

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## A METHOD OF DETERMINING THE EARLY REGENERATION OF NERVE FIBERS AT OPERATION \*

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ST. LOUIS

In an article which is to appear shortly in the *Archives of Neurology*, an instrument, called a "chronomyometer," for testing muscles whose nerve supply has been interfered with, is to be described. Evidence will be presented to show that when a nerve injury is complete and the patient is seen months after injury nonoperative treatment and careful electrical examinations are the procedures of choice, within certain limits. If, however, the nerve injury is complete and the patient is seen early, the method here described would seem to make early exploration of the nerve the method of choice.

When one explores an injured nerve and finds the nerve intact but thinned out or greatly thickened at some point, the question arises: Are axis cylinders passing through this area? If they are regenerating, the nerve should not be cut and resutured, but if they are not regenerating and sufficient time has elapsed to allow them to have grown through the suspected area, a secondary suture should be made. The next question which presents itself is: How are we to ascertain whether regeneration is occurring? At present, to my knowledge, the only method used is to stimulate the nerve trunk central to the lesion and note whether there follows any contraction of the muscles innervated by that nerve. Obviously, if regeneration were occurring but had reached, say, only half of the distance from the lesion to the muscles, no contraction would follow and one would proceed with the secondary suture. This would be doing the patient harm not only because it would delay regeneration many months but also because regeneration following a secondary suture is said to be not so promising as when the nerve trunk is intact. The delay in regeneration and the harm done the patient will vary with the distance between the suture line and muscles innervated by the nerve tested and the distance regenerating fibers had passed the point of injury. A case of brachial plexus injury illustrates this difficulty very well.

CASE 1. (Surg. No. B. II, 8213).—The patient had complete paralysis and anesthesia of the entire left arm two months after injury. The brachial plexus was explored and the three primary cords showed an area about 1 cm. in length

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\* From the Department of Surgery, Washington University School of Medicine.

which was about two thirds of the diameter of the remainder of the nerve trunk. This area did not appear to be normal nerve tissue, and stimulation of the nerve trunk failed to elicit any contractions of muscles. The thinned area was resected from one of the cords and a secondary suture inserted. Microscopic examination of the resected tissue revealed many axis cylinders, and one year later the patient showed marked regeneration of nerves both in those having their origin in the primary cord resected and from the primary cords that had not been resected, showing that the resection was unnecessary.

It is a well known fact that when a peripheral nerve is stimulated, by the application of cold to the skin in human beings or by direct stimulation of the trunk in animals, there is a reflex stimulation of the respiration, blood pressure and reflex contraction of muscles innervated by nerves other than the one stimulated. These phenomena are so well established and constant that it was felt that they might be used as an index of regeneration when the nerve trunk was exposed at operation.

#### EXPERIMENTS TO DETERMINE INDEX OF REGENERATION

With this in mind, eighteen experiments were performed on dogs and twenty-five tests were carried out on them. Different types of operation which had been performed for a study of methods of repair of peripheral nerve lesions are included in this series. The types of operation performed were: (1) end-to-end suture; (2) lateral anastomosis of the injured nerve into a slit in a normal nerve; (3) lateral anastomosis of the injured nerve to a flap cut in a normal nerve, and, (4) autotransplant of half of the central end of the injured nerve.

In each case the nerve was cut, repaired, and at varying intervals after operation, the test was applied. The test consisted in stimulating the normal central portion of the nerve with a faradic current which was just strong enough (threshold current) to stimulate definitely the respiratory center. This strength of current was then applied at varying distances distally from the suture line, and the central and peripheral effects recorded graphically or merely by inspection. The blood pressure was recorded in some cases. The physiologic results were checked up by histologic examination of the nerves which were stained by the pyridin-silver method of Ranson.<sup>1</sup> The condition of the reflexes, especially the corneal, were noted because the test is a reflex phenomenon, and the reflexes are depressed or paralyzed by deep anesthesia. Thus, the degree of anesthesia must be controlled so that the reflexes are very active.

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1. Ranson, S. W.: Degeneration and Regeneration of Nerve Fibers, *J. Comp. Neurol.* **22**:487, 1912.

TABLE 1.—TESTING NERVES AT OPERATION FOR PRESENCE OF AXIS CYLINDERS:  
CORNEAL REFLEXES VERY ACTIVE UNLESS OTHERWISE STATED

Exp. No.	Days After Repair	Distance of Axis Cylinders Below Suture Line Histologically	Muscle Contractions on Stimulation of Nerve Peripheral to Suture	Respiration on Stimulation of Nerve Peripheral to Suture	Blood Pressure on Stimulation of Nerve Peripheral to Suture	Remarks
1	234	To all muscles	+	Increase rate and depth	Increased	Response as with normal
2	169	To all muscles	+	Increase rate and depth	Increased	Response as with normal (good record of this)
3	157	To all muscles	+	No change	No change	Anesthesia deep
4	161	To all muscles	+	Increase in depth	Slight increase	Only 2 trials made with very weak current but response same as with this animal's normal nerves
5	152	To all muscles	+	Increase rate and depth	.....	On cutting tibial nerve central and waiting 18 days, muscular contraction weak and stimulation of respiration weak on stimulation of tibial peripheral
6	106	To all muscles	+	Increase rate and depth		
7	150	To all muscles	+	Increase rate and depth	Increased	Corneal reflex present (good record)
			+	Very slight increase depth	Not changed	Corneal reflex absent; stimulation was 3 cm. distal to suture line and response same with unrepai red nerves (good record)
8	150	To all muscles	+	Increase rate and depth	Slight increase	As strength of current increased so did the response; reaction same central to both suture lines as peripheral (good record)
9	120	To all muscles	+	Increase depth with slight slowing	Slight increase	Reaction same central as peripheral to suture lines (fair record only)
10	60	10-12 cm.	--	Increase rate and depth	Increased	Reaction same central as peripheral to suture lines; response better and stronger current used (good record)
11	60	10-14 cm.	—	Rate increase 12 per min. and decrease slight in depth with weak current; with strong current rate decreased 8 and increased depth	Rise of 5-10 mm.	Corneal reflex present (fair record)
				—	—	Corneal reflex absent (fair record)
12	3	0	±	—	—	
13	3	0	—	—	—	Usual change of blood pressure and respiration on stimulating 1 cm. central to sutures
14	90	To all muscles	+	48 per min. before and 60 per min. during stimulation		
15	60	To all muscles	+	Rate decreased 27 to 22, depth markedly increased		
16	60	To all muscles	+	Rate increased 36 to 48 per min		

TABLE 2. (Exp. 17).—LEFT SCIATIC CUT AT LEVEL OF MIDTHIGH AND END-TO-END SUTURE DONE, APRIL 14, 1921: CORNEAL REFLEXES VERY ACTIVE AND ANESTHESIA LIGHT DURING TESTS.

Date	Distance of Electrodes Distal to Suture Line	Stimulation of Respiration	Reflex Contraction of Muscles	Response of Muscles Innervated by Injured Nerve	Remarks
4/14/21	½ em.	Slight	Definite	Marked	No spread of current to central or peripheral ends when electrodes were placed 1 em. or more from suture line
4/21/21	3 mm. or more	None	None	None	Level where central effect disappeared sharply defined; histologic examination of nerve showed large number of axones 35 mm. distal to suture line and a few 45 mm. distal to suture line
4/28/21	3 mm. or more	None	None	None	
5/12/21	6 mm. or more	None	None	None	
5/27/21	35 mm. or more Less than 35 mm.	None Definite	None Definite	None None	

Summary: A threshold current applied 1 em. or more distal to the suture line does not spread to the central end at any time after complete injury to the nerve. The presence of regenerating axones could not be detected with certainty at the end of the fourth week but could be positively determined at the end of the sixth week (not tested at the end of the fifth week). When the physiologic response was present the axis cylinders were 10 mm. distal to the level at which the central effect could no longer be elicited.

TABLE 3 (Exp. 18).—LEFT SCIATIC CUT AT LEVEL OF MIDTHIGH AND END-TO-END SUTURE DONE APRIL 14, 1921: CORNEAL REFLEXES VERY ACTIVE AND DEPTH OF ANESTHESIA VERY LIGHT

Date	Distance of Electrodes Distal to Suture Line	Stimulation of Respiration	Reflex Contraction of Muscles	Response of Muscles Innervated by Injured Nerve	Remarks
4/14/21	½ em.	Slight	Definite	Marked	No spread of current to central or peripheral ends when electrodes were placed 1 em. or more from suture line
4/21/21	3 mm. or more	None	None	None	Level where central effect disappeared sharply defined; histologic examination of nerve showed large number of axones 15 mm. distal to suture line and a few 25 mm. distal to suture line
5/ 5/21	5-6 mm. or more	None	None	None	
5/20/21	20 mm. or more Less than 20 mm.	None Definite	None Definite	None None	

Summary: Same as in Experiment 17 except that regenerating fibers could be detected positively at the end of the fifth week. When the physiologic response was present the axones were from 5 to 10 mm. distal to level at which the central effect could not be elicited.

CASE 2 (Surg. No. B. H., 10589).—The patient had a brachial plexus injury of four years' standing. There was sensation to the midarm, very little voluntary movement in the muscles of the arm, but the chronomyometer test of the muscles of the arm showed a short nerve-muscle complex while the muscles in the forearm and hand did not show even the muscle complex. At operation for midarm amputation, the nervus cutaneus brachii medialis and nervus medius were stimulated with a faradic current at the level of the middle of the arm. No change in the respiration or muscular contractions was noted on stimulation of the nervus medius while stimulation of the nervus cutaneus brachii medialis

increased the rate of respiration from 18 to 38 per minute and the depth definitely. This change was so marked that it was seen by all present. Histologically, there were no axones in the nervus medius while there was a large number in the nervus cutaneus brachii medialis.

*Summary.*—Where there were no axones, no central effect was noted while a very definite central effect was noted when the normal nerve was stimulated.

#### COMMENT

A study of the tabulated results and protocols reveals these facts:

1—Stimulation of a peripheral nerve (normal or regenerating) has such a definite effect on the respiration in animals and human beings

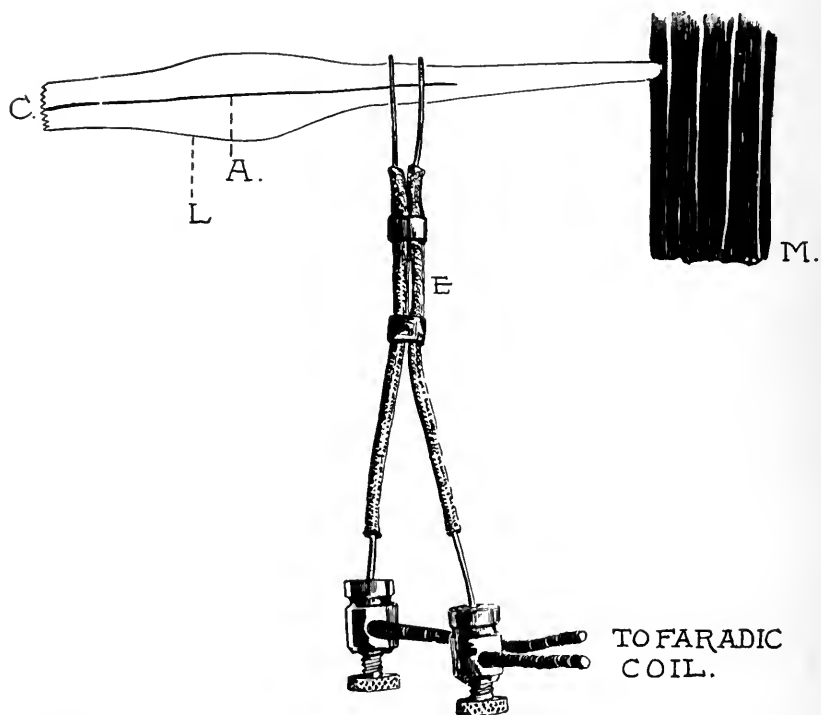


Diagram of method of reflexly stimulating the respiratory center when no contractions of the muscles are present: *A*, axis cylinder; *C*, central end of nerve; *E*, electrode applied to nerve below lesion *L*; *M*, muscle.

that it is easy to observe the effect, and thus a graphic record is unnecessary. The recording of the blood pressure changes is unnecessary.

2—Reflex contractions of muscles which receive their nerve supply from normal nerves or from branches of the nerve tested which leave the main trunk of the nerve central to the lesion are of definite value in determining the presence of regenerating fibers. This is very constant in its occurrence but is present only under the same conditions

as is the reflex stimulation of the respiration. The threshold of current necessary to cause reflex contractions is a little less than that necessary to affect the respiration.

3—Immediately after cutting a nerve and resuturing it, a threshold current spreads across the suture line, but after a week, there is no spread across the suture line when the electrodes are placed more than 3 mm. from the suture line. After five weeks, when regenerating fibers have passed the suture line from  $2\frac{1}{2}$  to 3 cm., there is a definite stimulation of the respiration and reflex contraction of muscles with a threshold current applied 2 cm. distal to the suture line. From this time on the reflex effect on respiration is always present and can be elicited at greater and greater distances distal to the suture line as regeneration progresses. Finally, when the regenerating axones reach the muscles, both their contractions and the central effect described above are present as in a normal nerve.

4—The strength of current used should not be stronger than that just necessary definitely to stimulate the respiration when applied to the normal portion of the central stump of the injured nerve (threshold current). The electrodes should be applied from  $1\frac{1}{2}$  to 2 cm. or more distal to the injured portion of the nerve in order to avoid any possibility of the current spreading to the normal nerve central to the lesion.

5—When the test is applied, the anesthesia should be light so that the corneal reflexes are very active, for the test depends on the reflex arcs being active. Deep anesthesia will paralyze the reflexes. The proper depth of anesthesia is reached when stimulation of the normal central portion of the injured nerve causes a reflex effect without too strong a current.

6—The test is of no service in a pure motor nerve as the facial, but is applicable to any sensory or mixed nerve.

7—Contractions of muscles innervated by the nerve tested when the nerve is stimulated peripheral to the suture line may be present up to three days following section of the nerve; but they then disappear until regenerating fibers reach the muscles months later.

#### SUMMARY

The results in Case 1 indicate that the test, as worked out on animals, is applicable to cases of peripheral nerve injury in man and should enable one to make a diagnosis weeks and months earlier than it has been possible to do up to the present, and thus in many cases should enable one to recognize early regeneration and avoid the hazards associated with a secondary suture by preventing one from placing a secondary suture in a nerve in which regeneration is already occurring.

It is of value, however, only after the fifth week following injury, when the nerve is explored and found to be intact. It should not be necessary to explore a case in which the paralysis is due to a physiologic block when the nerve-muscle complex can be demonstrated with the chronomyometer. On the other hand, if only the muscle complex is present five or more days after the injury, the nerve has degenerated and the nature of the injury to the nerve can only be determined by exploring it or by waiting many months to see whether regeneration will occur.

When a nerve injury is seen late the usual procedure has been to wait a reasonable time until there are evidences of regeneration. These may be detected earlier by means of the chronomyometer.

The method here described would seem to be particularly useful in early cases as the test was positive after five weeks in dogs. It is possible that this time interval may be somewhat longer in man.

The experience of Lewis<sup>2</sup> in a large series of cases has been that approximately 80 per cent. of nerve injuries recover spontaneously. This method merely involves exposing the injured nerve and would seem justified in many if not all cases of nerve injury since it would enable the surgeon to discover very much earlier the 20 per cent. of cases that need operation and save the patient much time.

In infected cases, of course, it could not be used until a clean field is assured.

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2. Lewis, Dean: *Peripheral Nerve Surgery*, S. Clinics, Chicago **3:769** (Aug.) 1919.



## INTESTINAL OBSTRUCTION \*

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DETROIT

A number of theories in explanation of the fundamental pathologic changes induced by intestinal obstruction have been developed in the last ten or twelve years. These theories represent the work and conclusions of many investigators, and no account of the subject would be complete which did not accord them due recognition and consideration. They may be briefly and conveniently classified under three general heads.

1. The theory of splanchnic paralysis and circulatory shock which conceded a place of primary importance to the distention and consequent circulatory disturbance in the bowel and their effect on the sympathetic nervous system through the nerve endings in the wall of the intestine. This theory is now of mere historical interest as a result of recent advances in our knowledge of the condition.

2. McLean and Andries<sup>1</sup> and Hartwell, Hogue and Beekman<sup>2</sup> arrived, each group independently of the other, at the conclusion that water loss from drainage of the body fluid into the intestinal lumen, above the obstruction, was the cause of the systemic symptoms and eventual death.

3. The latest, and at present most widely accepted, theory is that the symptoms are due to toxemia of duodenal origin. Dragstedt, Moorehead and Burcky<sup>3</sup> have found toxic bodies in the obstructed duodenum which they believe are the result of bacterial action on the duodenal proteins, both food remnants and tissues. Whipple<sup>4</sup> and his collaborators deny the influence of bacteria and have found powerful poisons of the proteose group in the intestinal lumen following experi-

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\* From the Buhl Memorial Laboratory, Harper Hospital.

1. McLean, Angus, and Andries, R. C.: Ileus Considered Experimentally, *J. A. M. A.* **59**:1614 (Nov. 2) 1912.

2. Hartwell, J. A.; Hogue, J. P., and Beekman, Fenwick: Experimental Study of Intestinal Obstruction, *Arch. Int. Med.* **13**:701 (May) 1914.

3. Dragstedt, L. R.; Moorehead, J. J., and Burcky, F. W.: Intestinal Obstruction, *J. Exper. Med.* **25**:421 (March) 1917.

4. Whipple, G. H.; Rodenbaugh, F. H., and Kilgore, A. R.: Intestinal Obstruction, *J. Exper. Med.* **23**:123 (Jan.) 1916.

mental obstruction. These poisons after filtration and reinjection into a healthy animal cause vomiting, diarrhea, rapidity of the pulse, collapse and other symptoms resembling those of intestinal obstruction. They conclude that the poisons are formed during a perverted activity of the lining cells of the duodenal mucosa and cause the toxic symptoms after absorption. Dragstedt<sup>5</sup> and other workers have since reaffirmed their belief in the bacterial origin of these poisons.

Later observations have led to the discovery that frequently intestinal obstruction is accompanied by remarkable changes in the concentration of the nonprotein nitrogen of the blood. This is not of constant occurrence, and intestinal obstruction may and does frequently exist when no significant changes in blood nitrogen concentration are present. In other cases, extreme rises are found such as occur in no other condition, uremia excepted. A pseudo-uremia, if such it may be termed, is present. These rises are in general associated with patients presenting the most severe systemic manifestations: rapid, feeble pulse and the general appearance of shock. The fundamental cause of, and precise indications for treatment conveyed by, this pseudo-uremia are at present questions of some uncertainty. Vaughan and Morse<sup>6</sup> find this concentration, particularly if repeated observations be made at intervals of a few hours, of value in both diagnosis and prognosis. Stone<sup>7</sup> considers it the cause of the constitutional symptoms and probably of death in uncomplicated fatal cases. Whipple and Cooke<sup>8</sup> have, by injection of proteoses isolated from the obstructed intestine, produced increased urinary and fecal elimination of nitrogen lasting for several days after injection. They believe it probable that the increase of blood nitrogen bodies in clinical cases of intestinal obstruction results from absorption of, and augmented protein destruction by, toxic substances elaborated in the duodenal mucosa under the conditions accompanying the obstruction.

#### EXPERIMENTAL WORK

Experimental work was undertaken to determine the influence, if any, of the water balance of the body on the progress of the condition and on the concentration and excretion of nonprotein blood nitrogen. Studies were made on dogs. All major operative procedures were

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5. Dragstedt, L. R.; Dragstedt, C. A.; McClintock, J. T., and Chase, C. S.: Intestinal Obstruction, *J. Exper. Med.* **30**:109 (Aug.) 1919.

6. Vaughan, J. W., and Morse, P. F.: Blood Nitrogen Estimations in Genito-Urinary and Abdominal Conditions, *Arch. of Surg.* **3**:405 (Sept.) 1921.

7. Stone, H. B.: Toxic Agents in Acute Intestinal Obstruction, *Surg., Gynec. & Obst.* **32**:415 (May) 1921.

8. Whipple, G. H., and Cooke, J. V.: Proteose Intoxication and Injury of Body Proteins, *J. Exper. Med.* **25**:461-479 (March) 1917.

carried out under ether anesthesia. All minor operative procedures were carried out under 1 per cent. procain anesthesia. All dogs under experimental observation were kept stupefied with chloral hydrate. All nitrogen estimations given are in milligrams of total noncoagulable nitrogen per hundred c.c. of blood or intestinal exudate, as the case may be, and were determined after the method of Folin.<sup>9</sup> No estimations of the various component fractions, as urea, creatinin and uric acid were made.

As an illustration of what may be expected in intestinal obstruction, blood nitrogen estimations made on a typical example, Dog 6, are given in Table 1.

TABLE 1.—BLOOD NITROGEN ESTIMATIONS IN DOG 6

No.	Time	Milligrams per 100 C.c.	No.	Time	Milligrams per 100 C.c.
1	Normal.....	30	4	72 hrs.*.....	86
2	24 hrs.....	55	5	96 hrs.....	92
3	48 hrs.....	85	6	120 hrs.....	150

This animal was operated on and a midjejunal obstruction produced by silkworm gut ligature about the intestine. He was penned up, and food and water left within reach. Nonprotein blood nitrogen estimations were made at twenty-four-hour intervals, the first normal, the last just preceding death. Necropsy revealed the obstruction intact, no gangrene nor perforation of the intestine, no peritonitis, no pneumonia.

In Dogs 1, 2, 3, 4 and 7 studies were made on well hydrated dogs with a measured fluid intake and output. Chemical studies were carried out on the fluid which drained into the intestinal canal to determine whether the nonprotein nitrogen bodies and their precursors in the path of protein disintegration accompanied the body fluids as they left the circulation and passed into the intestine. In all dogs, obstruction was produced by silkworm gut ligature about the intestine at the site designated. All fluid intake was given by saline hypodermoclysis to avoid the uncertainty accompanying the administration of water by mouth, much of which is immediately vomited or lies in the distended intestine and is never absorbed to become a part of the body fluid proper. The amounts given every twenty-four hours were roughly equal on a basis of comparative weights to a fluid intake of from 4,000 to 5,000 c.c. daily for a man weighing 150 pounds. This is greatly in excess of ordinary requirements without at the same time being more than a healthy circulation can absorb and distribute. Urinary output was collected by a retention catheter and the amount recorded every

9. Folin, O., and Wu, H.: A System of Blood Analysis, *J. Biol. Chem.* **38**:81 (May) 1919.

twenty-four hours, but no chemical studies were carried out on the urine. Intestinal drainage was collected in a bottle through a gastrotomy tube from the stomach, to which organ the fluid was carried from the site of excretion in the intestine by reverse peristalsis. All dogs were apparently in good health at the time of operation. The intestines

TABLE 2.—RESULTS OBTAINED WITH DOG 1 (MALE)\*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4 3/21	12 n.	450	...	...	22	...	...
	4 p. m.	150	...	...	...	...	...
	8 p. m.	300	...	...	...	...	...
4/4	8 a. m.	450	...	...	...	...	...
	12 n.	...	190	80	22.8	92	73.6
	4 p. m.	450	...	...	...	...	...
4 5	8 a. m.	150	...	...	...	...	...
	12 n.	450	65	350	40	23	80.5
	4 p. m.	300	...	...	...	...	...
4/6	8 a. m.	450	...	...	...	...	...
	12 n.	...	25	77	25	240	184.8
	4 p. m.	Died					

\*Operation was performed at 11 a. m., April 3, 1921; weight, 11,460 gm; ileocecal obstruction.

\*Necropsy revealed: Intussusception for 10 inches above obstruction with commencing gangrene but no perforation. There was no pneumonia. There was upper abdominal peritonitis. The urinary bladder was empty.

\*In Table 2 and in Tables 3, 4, 5 and 6, Column A represents the amount of saline given subcutaneously; B, urinary output; C, fluid output into the intestinal canal; D, concentration of total noncoagulable blood nitrogen in milligrams per hundred c.c.; E, the concentration of the same noncoagulable nitrogen bodies per hundred c.c. found in the intestinal fluid, and F, the absolute excretion of those bodies every twenty-four hours by the intestinal mucosa in milligrams.

TABLE 3.—RESULTS OBTAINED WITH DOG 2 (MALE)\*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4/8	4 p. m.	600	...	...	19	...	...
4/9	8 a. m.	450	...	...	...	...	...
	12 n.	...	325	150	31	86	129
	4 p. m.	450	...	...	...	...	...
	7 p. m.	Died	10	240	...	240	576

\*Operation was performed at 4 p. m., April 8, 1921; weight, 13,100 gm.; obstruction at end of jejunum.

\*Necropsy revealed: Obstruction intact; upper abdominal peritonitis; no pneumonia, and an empty bladder.

were in a typical fasting state and contained small amounts of semi-fluid contents; not more than 10 or 15 c.c. in any case. Any fluid of intestinal origin beyond this amount must, of necessity, have come from the body reserve through the circulation. The intake figures recorded are quite accurate; the output figures represent a minimum rather than

the actual amounts, as they take no account of water vapor in the expired air, small amount of semifluid discharges from below the obstruction and small amounts of vomitus which escaped collection by the gastrostomy tube. Blood nitrogen estimations were made at twenty-four-hour intervals: the first normal, the last just prior to death.

A study of these records will reveal several facts of interest. In the first place, while changes occurred in the concentration of blood nitrogen, they were all within normal limits with one exception, 55 mg. per hundred c.c., the final record in Dog 3, which will be considered presently. The final figure 41.5 mg., for Dog 7, is so slightly above the upper limit of normal, 40 mg., as to be within the limit of error of the method of estimation employed. In both these dogs, the circulation was, in the last hours of life, so rapid and inefficient as to be unable to absorb and distribute the subcutaneous saline. This remained at the site of

TABLE 4.—RESULTS OBTAINED WITH DOG 3 (MALE)\*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4/11	9 p. m.	500	...	...	24	...	..
4/12	8 a. m.	500	...	...	...	...	...
	12 n.	...	275	300	20	60	180
	4 p. m.	500	...	...	...	...	...
4/13	8 a. m.	500	...	...	...	...	...
	12 n.	...	425	430	35.5	46	197.8
	4 p. m.	500	...	...	...	...	...
4/14	8 a. m.	500	...	...	...	...	...
	12 n.	...	315	660	55	48	288
	4 p. m.	Died					

\*Operation was performed at 9 p. m., April 11, 1921; upper jejunal obstruction; weight, 15,430 gm.

\*Necropsy revealed: Obstruction intact; upper abdominal peritonitis; no pneumonia; urinary bladder empty.

administration in large edematous welts and, in consequence, whatever therapeutic value it possessed was not available beyond the localized area where it rested. It will be noted that Dogs 1, 2 and 3 suffered from peritonitis originating from leakage about the gastrostomy tube and complicating the obstruction. Dog 4 was killed with chloroform on suspicion that the obstruction had given way, which did not prove to be the case. Dog 7 had an extensive coexistent pneumonia. Vaughan has called attention to frequent rises in blood nitrogen during the last stages of a severe peritonitis. Myers<sup>10</sup> reports similar rises in unfavorable pneumonia cases. In neither of these conditions, however, does the rise attain the same magnitude as in intestinal obstruction. It seems probable that in both Dogs 3 and 7 the rise may be attributed to the

10. Myers, V. C.: Chemical Changes in the Blood in Disease, J. Lab. & Clin. Med. 5:418 (April) 1920.

complication rather than the primary obstruction. When compared to Dog 6, the standard, only a very mild nitrogenous toxemia exists. It furthermore seems probable that death, in all cases, was due to the complication rather than the obstruction. Hartwell and Hoguet have demonstrated that, in the absence of complications, large administrations of subcutaneous saline serve to prolong the life of dogs with intestinal obstruction indefinitely. We believe also that in the absence of com-

TABLE 5.—RESULTS OBTAINED WITH DOG 4 (MALE)\*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4/17	12 n.	500	...	...	28.6	...	...
4/18	8 a. m.	450	...	...	...	...	...
	12 n.	150	190	780	37.5	86	670.8
	4 p. m.	450	...	...	...	...	...
4/19	8 a. m.	450	...	...	...	...	...
	12 n.	...	32	490	29	43	210.7
	4 p. m.	450	...	...	...	...	...
4/20	8 a. m.	600	...	...	...	...	...
	12 n.	...	...	450	35.5	60	270
	4 p. m.	300	...	...	...	...	...
4/21	8 a. m.	450	...	...	...	...	...
	12 n.	...	...	300	28	92	186
	4 p. m.	450	...	...	...	...	...

\*Operation was performed at 12 n., April 17, 1921; weight, 12,220 gm.; midjejunal obstruction.

\*The dog was killed with chloroform at 4:30 p. m. Necropsy revealed: No pneumonia, no peritonitis, obstruction intact, small amounts of urine passed after April 19, but not recorded because of breaking of catheter.

TABLE 6.—RESULTS OBTAINED WITH DOG 7 (MALE)\*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
5/1	1 p. m.	450	...	...	23	...	...
	8 p. m.	300	...	...	...	...	...
5/2	8 a. m.	450	...	...	...	...	...
	12 n.	...	200	380	28	60	288
	4 p. m.	450	...	...	...	...	...
5/3	8 a. m.	450	...	...	...	...	...
	12 n.	...	175	445	27	44.5	198
	4 p. m.	450	...	...	...	...	...
5/4	8 a. m.	450	...	...	...	...	...
	12 n.	...	155	750	22.2	35.3	254
	4 p. m.	450	...	...	...	...	...
5/5	8 a. m.	450	...	...	...	...	...
	12 n.	...	195	720	30	44.5	320
	4 p. m.	450	...	...	...	...	...
5/6	8 a. m.	450	...	...	...	...	...
	12 n.	...	150	700	41.5	50	350
	4 p. m.	450	...	...	...	...	...

\*Operation was performed at 1 p. m., May 1, 1921; weight, 9,625 gm.; midduodenal obstruction.

\*The dog died at 4:30 p. m. Necropsy revealed: Obstruction intact; no peritonitis; pneumonia in right lower and middle lobes; urinary bladder empty.

plications, sufficient water serves to maintain the noncoagulable nitrogen of the blood within normal limits as it has in four of the five cases submitted. Further support for these statements will be offered shortly.

A second feature of interest is the outpouring of body fluids into the intestinal canal above the obstruction, amounting frequently to many times the urinary output every twenty-four hours. This is an occurrence which may be recognized clinically and is merely mentioned in passing. It may be seen that, in clinical cases, unless the fluid excreted into the intestine is replaced, a severe dehydration will rapidly occur; again that administration must be made by a route other than the mouth because ingested fluids are either vomited at once or lie in the distended intestine without being absorbed, since the intestinal mucosa is largely or entirely given over to excretion.

Thirdly, bodies of the nonprotein nitrogen group are found in this exudate; bodies responding to the same chemical tests which identify the waste nitrogen of the blood. The two are undoubtedly identical and pass from the blood stream into the intestine in solution with the fluid drainage. Reference to the foregoing tables will also reveal that at times the nonprotein nitrogen of the intestinal fluid exists in greater concentration than it does in the blood. The importance of this fact will be discussed later.

It becomes evident, after a study of Dogs 1, 2, 3, 4 and 7, that the rise of noncoagulable blood nitrogen in intestinal obstruction is profoundly influenced if a large supply of water is assured. If not entirely checked, it is at least minimized. As a result, it was decided to try the effect of severe water loss in the absence of intestinal obstruction. Accordingly, three dogs were penned up and permitted to die of thirst by merely withholding water. Blood nitrogen records are given in Table 7.

In the figures in Table 7 the first is normal, the succeeding readings were taken at twenty-four-hour intervals. The last in each series was taken just prior to death.

In this series we find the nonprotein nitrogen of the blood rising to concentrations quite similar to those of intestinal obstruction, Dog 6. Dog 11 was under observation during cool, moist weather and was almost totally inactive, making water loss very slow. Moreover, we cannot be certain that he did not obtain water on several occasions, and the presumption is that he did. The end-result was the same, however, and when thirst became severe the animal promptly developed a pseudo-uremia.

Since simple thirst when severe causes a rise of waste nitrogen in the blood to uremic heights, it was thought wise to try forced dehydra-

tion after the technic of Balcar, Sansum and Woodyatt<sup>11</sup> in their investigation of dehydration fever. These workers, by the intravenous injection of concentrated salt or glucose solutions, caused a urinary output which rapidly became greater than the fluid intake. Remarkable increases of temperature resulted after the dehydration had amounted to 30 or more cubic centimeters per kilogram of body weight. To their technic, we have added the estimation of nonprotein nitrogen in samples of blood taken at intervals between the start of the experiment and the death of the experimental animal.

TABLE 7.—BLOOD NITROGEN ESTIMATIONS IN DOGS DYING OF THIRST

Dog 11	Dog 13	Dog 15
Milligrams per 100 c.c.	Milligrams per 100 c.c.	Milligrams per 100 c.c.
18	26	24
22.2	21.4	28.6
22.2	30	32.5
24	44.5	43
25	32	53.5
30	43	133
27.3	70	
28.6	120	
41.5		
34.8		
52		
43		
40		
30		
33.4		
36		
38.5		
60		
100		
200		

## REPORT OF EXPERIMENTS

EXPERIMENT 1.—In Dog 8, male, weight, 11,340 gm., a solution containing 5 per cent. sodium chlorid and 0.7 per cent. lactic acid was injected intravenously at the rate of 150 c.c. per hour. Injection was started at 5:40 p. m. At 8:30 p. m., the urine which was collected through a catheter showed traces of blood. About the same time a chill began, which rapidly reached convulsive violence. The temperature, 102.2 F., at the start of the experiment, rose rapidly to 111.2 F., at 9:20 p. m. Death occurred at this point. During this time 500 c.c. of solution was injected intravenously, and 580 c.c. of urine was passed. The output exceeded the intake by 480 c.c., or 42 c.c. per kilogram of body weight. Nonprotein blood nitrogen at the start of the experiment was 23 mg. per hundred c.c. Just prior to death, it had reached 31.5 mg. per hundred c.c.

The data for other dogs will be given in tabular form.

11. Balcar, J. O.; Sansum, W. D., and Woodyatt, R. T.: Fever and the Water Reserve of the Body, *Arch. Int. Med.* **23**:116 (July) 1919.



EXPERIMENT 2.—Dog 10, female, weight, 9,725 gm., was injected with a fluid the formula of which was: Sodium chlorid, 88.32 gm., potassium chlorid, 1.98 gm., calcium chlorid (anhydrous), 1.5 gm., hydrochloric acid, 40 c.c., and water, 2,000 c.c.

TABLE 8.—RESULTS OF FORCED DEHYDRATION IN DOG 10\*

Time	Temp.	A	B	C	D
		C. c.	C. c.	C. c.	Mg.
3:00 p. m.	101.4	0	0	0	20
7:45 p. m.	105.8	510	1180	68	36

\* In this table and in Tables 9, 10 and 11, column A gives fluid intake at the time stated; B, urinary output; C, dehydration in c.c. per kilogram of body weight; D, nonprotein blood nitrogen in milligrams per hundred c.c. Columns A and B are given as cumulative quantities. The first figure in each column is the normal; the last figure is at the time of death.

EXPERIMENT 3.—Dog 16, male, weight, 12,325 gm., was injected with a dehydration fluid composed of sodium chlorid, 99 gm.; potassium chlorid, 3.30 gm.; calcium chlorid (anhydrous), 2.86 gm.; water, 2,000 c.c.

TABLE 9.—RESULTS OF FORCED DEHYDRATION IN DOG 16\*

Time	Temp.	A	B	C	D
		C. c.	C. c.	C. c.	Mg.
12:00 n.	101.8	0	0	0	30
2:00 a. m.	101.8	200	130	—5.6	30.8
4:00 a. m.	102.2	400	520	9.7	30.8
6:00 a. m.	100.4	450	790	27.6	31.5
8:00 a. m.	99.6	450	835	31.2	32.5
10:00 a. m.	99.6	450	860	33.3	33.4
12:00 a. m.	99.8	450	875	34.6	37.5
2:00 p. m.	101.0	450	880	34.9	43.0
4:00 p. m.	101.6	450	880	34.9	48.0
6:00 p. m.	102.6	450	880	34.9	57.0
6:45 p. m.	103.4	Died			75.0

EXPERIMENT 4.—Dog 20, male, weight, 4,645 gm., was injected with a dehydration fluid composed of 35 per cent. glucose solution of which enough was given to provide 6 gm. of glucose per kilogram of body weight.

TABLE 10.—RESULTS OF FORCED DEHYDRATION IN DOG 20\*

Time	Temp.	A	B	C	D
		C. c.	C. c.	C. c.	Mg.
3:20 p. m.	101.2	0	0	0	28.6
4:10 p. m.	101.4	80	130	10.9	..
7:20 p. m.	100.4	80	233	33.2	30
11:20 p. m.	100.4	80	254	37.8	35.3
3:20 a. m.	101.0	80	273	41.9	46.0
7:20 a. m.	101.4	80	286	44.7	60.0
11:20 a. m.	102.4	80	292	46.0	63.0
1:30 p. m.	103.6	80	295	46.7	92.0

EXPERIMENT 5.—Dog 23, female, weight, 13,520 gm., was injected with a dehydration fluid composed of 35 per cent. glucose solution of which enough was given to provide 6 gm. of glucose per kilogram of body weight.

TABLE 11.—RESULTS OF FORCED DEHYDRATION IN DOG 23\*

Time	Temp.	A C. c.	B C. c.	C C. c.	D Mg.
10:30 p. m.	101.2	0	0	0	25
7:00 a. m.	101.0	230	355	9.26	37.5
3:00 p. m.	102.6	230	390	11.85	70
8:00 p. m.	104.0	230	412	13.5	75
10:30 p. m.	105.4	230	416	13.8	86
11:30 p. m.	105.8	230	422	14.2	100

In these five experiments it will be noted that marked rises in concentration of the nonprotein blood nitrogen occurred. Dog 8 showed a rise of 8.5 mg., or 37 per cent., during three hours and forty minutes. Dog 10 showed 16 mg., or 80 per cent. rise, in four hours and forty-five minutes. The other three dogs gave rises of 150 per cent., 212 per cent. and 300 per cent. during eighteen and three-fourths hours, twenty-two and one-half hours and twenty-five hours, respectively; all occurring as a result of water loss. Acidosis, while it might have increased as a result, apparently had little influence as a causal factor. It is also apparent that in the more rapid dehydrations the initial rise was greater than in the other cases, but not so well sustained on account of the early death of the animal and consequently the same heights were not reached.

#### COMMENT

It seems clear from an experimental standpoint that water deprivation is the most important, if not the sole, factor in the production of the pseudo-uremia of intestinal obstruction. Waste nitrogen increase in the blood is prevented by an assured water supply during obstruction or is produced in the absence of either obstruction or a preexisting nephritis by severe water loss. Renal changes are undoubtedly present, but must result largely from the almost total absence of available water and the high concentration of the toxic waste products in the blood. The diminished urinary output of intestinal obstruction is also undoubtedly traceable to the large intestinal output of water and the resultant dehydration.

Viewed in this light, the condition becomes a pseudo-uremia of thirst rather than of intestinal obstruction; an increase in the rate of protein catabolism where insufficient fluid exists combined with a lack of water as a vehicle for excretion of the toxic split products as they accumulate in the blood. Why protein destruction should occur so much more rapidly in the absence of an ample water supply is, at present, not entirely clear. The answer probably rests in the field of colloidal chemistry. A more or less cursory search of the literature has

failed to throw light on the question, but a tentative explanation may be offered for use until the chemists shall have either confirmed or disproved it:

Proteins exist *in vivo* as complex nitrogenous bodies of low osmotic pressure. They are loosely combined with small amounts of water; the so-called water of hydration, which is essential to the stability of the molecule. It is also safe to state that protein metabolism, while it may be minimized, can never be entirely eliminated; witness the impossibility of reducing the nonprotein nitrogen of the blood beyond certain low limits, perhaps 15 or 16 milligrams per hundred c.c. by any device of protein free diet, forced fluid intake or other measures. In the presence of a continued elimination of urinary nitrogen, this can mean but one thing; protein disintegration. If fresh water is not forthcoming at frequent intervals, the available water supply of the body is gradually exhausted through the urine, expired moisture and sweat. At this point, an increase in the waste nitrogen of the blood will commence from simple retention because of lack of a vehicle for excretion. It seems probable that repeated small increments of such substances as urea, creatinin and uric acid would cause a rise in the osmotic pressure of the remaining body fluids to that point at which the proteins gave up their water of hydration to the superior force and commenced to break down as a result. The intravenous injection of concentrated salt or glucose solution would not only expedite water loss but would also cause a rapid artificial rise of osmotic pressure in the body fluids. To resume, this breakdown of protein would in turn cause an increased production of waste nitrogen, a further rise in the osmotic pressure of the body fluids and a more widespread attack on the remaining protein. It culminates in a truly vicious circle which gains momentum as it goes and can be broken only by the administration of water. Reference to the experimental records will show that the reaction actually increases in velocity in the later stages as evidenced by the accumulation of waste nitrogen. Although a discussion of nephritis is not within the scope of this paper, it is possible that a similar mechanism may be operative in the production of uremia, once an appreciable retention has occurred.

Turning momentarily from the subject of protein disintegration to that of the excretion of the waste products during intestinal obstruction, it is found that these, together with the major portion of the body's fluid output, pass into the intestine above the obstruction. If, at any time, water loss causes them to assume an increased concentration in the blood, renewed aqueous intake will cause a fresh outpouring of fluid and a washing out of the accumulation of waste. While no search has been made for intermediate products of protein destruction,

such as proteoses, they must be formed at some stage of the catabolic process, and no reason is apparent why they should not accompany the simpler waste products in their passage into the intestine. Appropriate chemical methods have already demonstrated the presence of such substances in the fluid excreta. These, we are inclined to think, constitute the duodenal toxins found by other workers and are not formed *in situ* by the cells of the intestinal mucosa, but excreted by them from the blood stream into the intestine. There is no definite proof of the existence of toxins formed *in situ*, and even if present, it is difficult to believe they could be absorbed against the outpouring current.

To renew the consideration of protein destruction in dehydration, this phenomenon may be traced through various apparently unrelated conditions and is of sufficient importance to warrant a digression from the subject of intestinal obstruction. First in importance is the question of fever and the mechanism whereby it is produced. Vaughan<sup>12</sup> has caused fever by the injection of small quantities of protein. Balcar, Sansum and Woodyatt found it to result from severe dehydration which they believed to be the determining factor. It is now apparent that water loss causes the destruction of protein, and it seems probable that the two theories may be unified and that dehydration through the resulting protein disintegration causes fever after the theory of Vaughan. This must be aggravated by the absence of water with its high specific heat, and the body in consequence lacks an agent for absorption and transportation of the excess calories to the surface where they may be radiated, as explained by the Chicago workers.

There is available for discussion what is undoubtedly a clinical example of fever following dehydration; namely, heat stroke or thermic fever. This occurs during the torrid spells of summer or in those working under conditions of high artificial heat as found in engine rooms or the like. Actual heat stroke is usually preceded by profuse and prolonged sweating. The victim is then seized by a chill, which may result in high fever, temperatures of 107 or 108 F. being frequently recorded. Gradwohl and Schisler<sup>13</sup> have noted that in heat stroke tremendous rises occur in the urea nitrogen of the blood. These facts when considered together make it seem probable that the condition is but an example of a general physiologic response to water loss; the disintegration of protein with the production of fever when a

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12. Vaughan, V. C.; Vaughan, V. C. Jr., and Vaughan, J. W.: Protein Split Products in Relation to Immunity and Disease, Philadelphia, Lea and Febiger, 1913, pp. 373-415.

13. Gradwohl, R. B. H., and Schisler, E.: A Study of Thermic Fever, *Am. J. M. Sc.* **154**:407 (Sept.) 1917.

sufficient velocity of reaction is attained. Woolley<sup>14</sup> has, indeed, suggested an explanation identical with that mentioned above in an effort to make clear the pathology of heat stroke. In this connection, it is interesting to note that fever in intestinal obstruction, usually considered diagnostic of peritonitis or other complications, may be of aseptic origin. If, at any time, the accompanying water loss causes the body protein to break down with sufficient rapidity, fever will result in the absence of infection.

Still other conditions, for instance peritonitis and pneumonia, occasionally exhibit definite rises in concentration of the nonprotein blood nitrogen and the cause for them has in the past been most uncertain. They are usually, however, associated in both conditions with unfavorable cases and carry with them a grave prognosis. In peritonitis, the patients are apt to be those who vomit frequently and take water poorly. In both diseases, the pulse may be so rapid and the circulation so inefficient as to distribute the fluids at hand very imperfectly. Studies in cardiac efficiency by various workers have shown that a rapid heart beat gives an inefficient circulation and that when cardiac edema exists a slowing of the pulse increases circulatory efficiency and thereby aids in absorption of the fluid deposit. Conversely, an increase in the heart rate may permit more fluid to leave the vessels and gravitate to the dependent portions of the body with production of a regional dehydration when no general dehydration exists. Hence, the circulatory condition may offer one cause for water shortage.

If we may use for our purposes a portion of the theory of Balcar, Sansum and Woodyatt, another possibility becomes apparent. These workers suggest that the body water exists in two forms, first free and uncombined, in which state it is available for purposes of heat absorption and transportation; second, in colloidal combination with the proteins, glycogen, etc., which destroys its ability to regulate heat. They think it possible that infection so poisons these hydrophilic colloids as to increase their hydration capacity, thereby leaving a scarcity of free water, and point to the water retention of pneumonia, with its suddenly enhanced excretion as sweat and urine at the crisis, for support. If this theory approximates the truth, and the necessary water of hydration for the proteins were to be largely increased, some portions might be unable to secure the necessary fluid. In such a case, it might be expected that they would commence to disintegrate, perhaps with the production of fever, certainly with increased formation of nitrogenous waste. Any or all of the above mentioned factors may influence the formation of

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14. Woolley: Cited by McKenzie, Pierce, and LeCount, E. R.: Heat Stroke, J. A. M. A. **71**:260 (July 27) 1918.

excess blood nitrogen in the two diseases under discussion, and the remedy is water although various difficulties, both mechanical and chemical, may interfere with the administration.

Again Minsk and Sauer<sup>15</sup> report that the nonprotein nitrogen of the blood in atrophic infants rises at times, and if over 30 milligrams per hundred c. c. carries with it an unfavorable prognosis. Once more a nonnephritic rise of the blood nitrogen is found and one which probably results from a disturbance of water balance.

The list of conditions in which water loss may cause protein destruction, accumulations of waste nitrogen in the blood and at times fever will doubtless be much enlarged by future observers. In this article have been included a few probable examples to illustrate the possibilities of the situation.

#### CONCLUSIONS

1. The rise in concentration of nonprotein blood nitrogen observed in intestinal obstruction is due, not to that condition *per se*, but to the accompanying water loss.

2. An increase of blood nitrogen in intestinal obstruction may be prevented by the administration of sufficient water.

3. An increase of blood nitrogen may be experimentally produced in the absence of intestinal obstruction or of a preexisting nephritis by the adoption of any measure calculated to produce severe thirst.

4. Death from intestinal obstruction is, in the absence of complications, due to toxemia from the protein disintegration which occurs after severe water loss. It is the most common clinical example of death from thirst.

5. The toxic nitrogenous residue is excreted from the blood stream by the intestinal mucosa into the intestine where it may exist in higher concentration than in the blood. If not drained out, on relief of the obstruction, the material may be reabsorbed by the lower bowel and colon, causing an increase of the already existing toxemia.

6. Fever in intestinal obstruction may be of aseptic origin and indicate nothing more than the protein disintegration occurring in severe dehydration.

7. An increase in the noncoagulable blood nitrogen of diverse conditions, as heat stroke, peritonitis, pneumonia and the atrophy of infancy, depends on low water reserve and in the absence of nephritis may be used as a reliable guide for the administration of water.

8. The two chief theories of fever, the protein theory of Vaughan and the dehydration theory of Balcar, Sansum and Woodyatt, may be unified by showing that the latter depends on the former.

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15. Minsk, L. D., and Sauer, L.W.: Nonprotein Nitrogen of the Blood in Atrophic Infants, *Am. J. Dis. Child.* **13**:397 (May) 1917.

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